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US Army Corps of Engineers
Los Angeles District

SANTA ANA RIVER BASIN, CALIFORNIA

Santa Ana River

AD-A211 754

Design Memorandum No. 1

PHASE II GDM ON THE SANTA ANA RIVER MAINSTEM including Santiago Creek

VOLUME 6
SANTIAGO CREEK

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August 1988

REPORT DOCUMENTATION PAGE

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This volume accompanies the Main Report and Supplemental Environmental Impact Statement for the Phase II General Design Memorandum for the Santa Ana River Mainstem including Santiago Creek and contains the general design for the Santiago Creek.

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DESIGN MEMORANDUM NO. 1
VOLUME 6

SANTA ANA RIVER MAINSTEM
INCLUDING SANTIAGO CREEK, CALIFORNIA

PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK

SYLLABUS

This volume accompanies the Main Report and Supplemental Environmental Impact Statement for the Phase II General Design Memorandum for the Santa Ana River Mainstem including Santiago Creek and contains the general design for the Santiago Creek. The project economic data is presented in volume 9.

The recommended plan for Santiago Creek consists of modifying the existing gravel pits for flood control storage, constructing an outlet structure from the gravel pits with a release capacity of 3500 ft^3/s and constructing a riprapped channel between the Santa Ana Freeway and the confluence with the Santa Ana River. The 5.5 miles of creek between the outlet structure and channel in the vicinity of Walnut Avenue to the beginning of the riprapped channel south of the Santa Ana Freeway would not be improved and would be managed by the local sponsor in accordance with FEMA guidelines.

PHASE II GDM LISTING OF VOLUMES

Main Report and Supplemental Environmental Impact Statement	
Volume 1	Seven Oaks Dam
Volume 2	Prado Dam
Volume 3	Lower Santa Ana River (Prado Dam to Pacific Ocean)
Volume 4	Mill Creek Levee
Volume 5	Oak Street Drain
Volume 6	Santiago Creek
Volume 7	Hydrology
Volume 8	Environmental
Volume 9	Economics and Public Comment and Response

PERTINENT DATA
SANTIAGO CREEK

Item	
Drainage Area at	
Villa Park Road	91 sq. mi.
Prospect Street Outlet	95 sq. mi.
Top of Conservation Pool (Varied with time of year)	elevation 274-293 feet
Top of Flood Control Pool	elevation 298 feet
Flood Control Storage (Between elevation 274-298 feet)	4,620 acre-feet
Reservoir Area (Elevation 298 feet)	92 acres
Outlet Structure	
Invert	elevation 267.5
Top of Entrance Chamber	elevation 300
Gates	
Transferable Bulkhead	1-20 feet wide x 16 feet high
Radial	2-20 feet wide x 12 feet high
Concrete Channel	
Length	500 feet
Base width	varies 30 feet to 40 feet
Riprap Channel	
Station 293+15 to 252+00	
Length	4,115 feet
Base Width	30 feet
Station 74+35 to 10+15	
Length	6420 feet
Base Width	Varies 30 feet to 80 feet

CONTENTS

Contents (Continued)

Contents (Continued)

Contents (Continued)

Tables

Contents (Continued)

Figures

Plates

Contents (Continued)

Plates (Continued)

Appendices

I. INTRODUCTION

Authorization

1-01 Authorization for construction of this project was contained in the Water Resources Development Act of 1986, (99th Congress 2nd Session, PL 99-662. The project for flood control is contained in the Report of the Chief of Engineers for the Santa Ana River Mainstem, including Santiago Creek, California, dated January 15, 1982, except that, in lieu of the Mentone Dam feature of the project, the Secretary is authorized to plan, design, and construct a flood control storage dam on the upper Santa Ana River. The full authorization language is presented in the Main Report.

Scope and Purpose of Report

1-02 This volume of the Phase II General Design Memorandum (GDM) describes the latest existing condition and environmental conditions in the project area and provides definite design for Santiago Creek. In addition, the detailed design for the flood control channel has been revised, refined, and presented to reflect the latest conditions and the desire of local citizens.

1-03 The purpose of this report is to provide the basis for (1) delineation and determination of the project rights-of-way and easement, (2) an up-to-date assessment of environmental and economical effects, (3) updating the project costs, and (4) preparation of construction plans and specifications.

Local Cooperation

1-04 The division of the Federal and non-Federal responsibilities for local cooperation are shown in the Main Report.

II. PROJECT PLAN

Description of Project Area

2-01 Santiago Creek is the largest tributary of the Santa Ana River downstream of Prado Dam. The headwater of the creek is in the vicinity of Santiago Peak of the Santa Ana Mountains in the northeastern part of Orange County. The stream flows in the northwest direction for a distance of approximately 15 miles to Villa Park Road in the City of Orange, then turns southwest for about another 7 miles before joining the Santa Ana River in the City of Santa Ana. The total drainage area of Santiago Creek is about 102 mi^2. The runoff from 80 percent of the drainage area is partially controlled by the existing Santiago Dam (a water supply reservoir built by the Irvine Company in 1933) and Villa Park Dam (a flood control structure constructed by Orange County in 1963). The drainage area remaining downstream from Villa Park Dam is approximately 19 mi^2.

2-02 Upstream from Villa Park Dam, the creek flows through a mountainous area with steep slopes generally devoid of urban development. Downstream from Villa Park Dam, Santiago Creek continues to flow along a narrow streambed in a hilly area with steep canyon walls for about 1.5 miles before reaching the alluvial fan at the northeastern part of the City of Orange. Due to the vast deposit of high quality sand and gravel along the streambed from Villa Park Road to the vicinity of Walnut Avenue, extensive commercial mining of the deposited material for construction has been going on for several decades. There are three large gravel pits located between Villa Park Road and Walnut Avenue. The Blue Diamond Pit (located just downstream from Villa Park Road) and Bond Pit (located upstream from Prospect Street) have a combined volume of approximately 12,000 acre-feet between the bottom of pits at about elevation 170 and the top at elevation 300 shown on plate 2. These pits are well entrenched and form an effective flood control reservoir which could retain the entire volume of small floods, preventing streamflows from overflowing and causing damage to downstream properties. However, the flood control value of these pits decreases as soon as they are partially or completely filled by preceding storms.

2-03 As a result of rapid urban development of southern California including Orange County over the last 40 years, development has encroached on the floodplain of Santiago Creek from Walnut Avenue to the Santa Ana River, a distance of approximately 4.6 miles. In addition to residential and commercial development within this reach, there are three major highway crossings (Newport Freeway, Garden Grove Freeway, and Santa Ana Freeway), two active railroad lines (Southern Pacific and Santa Fe) and eight street bridges (Chapman Avenue, Tustin Avenue, Cambridge Street, Glassell Street, Santiago Street, Main Street, Flower Street, and Bristol Street). Although all bridge crossings were designed to have sufficient cross sectional capacity to convey the design flood, their locations prevent realignment of the channel for effective floodflow and minimizing bank erosion.

Existing Flood Control Facilities

VILLA PARK DAM

2-04 Villa Park Dam is owned and operated by Orange County Environmental Management Agency. The dam is located approximately 2.7 miles upstream from Villa Park Road and 3.4 miles downstream from Santiago Dam, an existing water supply reservoir. Villa Park dam has a total drainage area of about 83 mi^2 of which 63 mi^2 are upstream from Santiago Dam. The existing flood control dam has an earthfilled embankment with its top at elevation 584.25 above the National Geodetic Vertical Datum (NGVD) of 1929. A detached concrete-rectangular spillway located on the right abutment of the dam has an ogee crest with a length of 200 feet at elevation 566 feet. At this elevation, the reservoir has a capacity of approximately 16,000 acre-feet. The spillway was designed to convey a peak discharge of 29,000 cubic feet per second (ft^3/s) with a surcharge of 11 feet. The outflow from the gated 13 x 13-foot outlet conduit with the intake of elevation 486 feet is regulated by three 6 x 12-foot hydraulic slide gates capable of releasing 6,000 ft^3/s.

GRAVEL PITS

2-05 The Blue Diamond and Bond pits were created by years of mining of sand and gravel adjacent to the streambed area, and were not designed as water storage structures. Due to their location and size, the pits have provided storage capacity for streamflow resulting in the reduction of the peak discharge in the creek downstream from the pits. In order to convey streamflows into the pits, a 21-foot diameter corrugated metal culvert under Villa Park Road was provided by local interests. The culvert, which has an intake at elevation 248.5 and outlet at elevation 240 feet, is 56 feet below the top of road (elevation 305 feet). Hydraulic calculations indicate that the conduit is capable of conveying the design flood.

2-06 Three large corrugated metal pipes under Prospect Street currently serve as the outlet from the gravel pits. There are two 19 x 12-foot arch pipes with an inlet and outlet at elevations 284 and 281, respectively, and an 18 x 14-foot arch pipe with about the same inlet and outlet elevations. The three pipes together have a discharge capacity of 7,000 ft^3/s with the water surface equal to the top of the street at elevation 300 feet.

Channel Improvements

2-07 Existing flood control structures along portions of Santiago Creek are very extensive and were constructed a long time ago. Some of the existing cobblestone and concrete walls along the toe of existing banks were probably built in the 1930's. Although detailed construction drawings of these walls are no longer available, these walls are still functional and providing protection for the existing banks.

2-08 From Walnut Street (sta. 263+00) to the vicinity of Shaffer Street (sta. 151+00) (shown on pls. 11 through 14), the existing creek remains more or less in its natural course and cross section over a distance of approximately 2.1 miles except at (1) the Santiago Golf Course (between channel sta. 192+00 and sta. 152+00), (2) all bridge crossings (Chapman Avenue at sta. 228+08, Newport Freeway at sta. 213+20, Tustin Avenue at sta. 192+87, and Cambridge Street at sta. 164+42), and (3) scattered bank protection provided for individual existing housing tracts. Hydraulic calculations indicate that the maximum water surface for the 100-year design flood would be confined within the existing banks and would not cause any damage to adjacent properties or facilities. Three localized bank protections are provided in this reach of Santiago Creek. First, one located on the south bank of the Creek just upstream from Tustin Avenue is an 1800-foot long revetment with a 24-inch grouted stone over 6 inches of filter blanket with the toe extended 9 feet below the streambed. The protection was constructed by a private developer in 1979, and Orange County Environmental Management Agency is responsible for maintenance of the protection. The second bank protection is situated on the north end of the creek between station 157+30 and station 151+70 immediately upstream of Shaffer Street. This 560-foot long bank protection consists of 2-foot-thick stone blanket over 6 inches of filter blanket. A 6-foot-wide horizontal toe was provided at 7 feet below the streambed. This protection was constructed by a private developer. The third bank protection was constructed by the City of Orange in 1979 for the south bank of the creek between station 152+00 and station 160+50. The protection consists of 24 inches of riprap over 6 inches of filter blanket, with the toe extending to 3 feet below the existing thalweg of the creek.

2-09 Approximately 1,600 feet of the Santiago Creek streambed between Shaffer Street (sta. 151+00) and Glassell Street (sta. 134+93) was paved with asphalt and is utilized for parking. The lined channel has a width of approximately 90 feet with 6-foot high cobblestone walls. Detailed construction drawings of the walls do not exist. It appears that the walls were built before 1940. Although in the floodway, this parking area has been used successfully both as a channel and a parking area for visitors to Hart Park during the dry summer season over the last several decades. Dual use of the streambed is expected to continue in the future. Computed water surface of the 100-year design flood indicates that the cross section of the channel through this parking area would be adequate for conveyance of the design flood without overtopping the cobblestone walls.

2-10 Between Glassell Street (sta. 134+93) and Santiago Street (sta. 109+93), over a distance of approximately 2,500 feet, both banks of Santiago Creek are protected by existing concrete gravity walls. These walls have a height of about 8 feet above the existing ground surface and a top width of one foot. The exact dimension and construction details of these walls are not available. The walls were constructed prior to 1940. Over the past 40 years, the walls have been stable, and the channel is large enough to convey the design flow of 4,000 ft^3/s.

2-11 From Santiago Street (sta. 109+93) to Main Street (sta. 85+35), concrete masonry walls were built along both banks of the creek. Available drawings dated March 1947 indicate that these walls were in existence then. A typical wall section consists of a 30-inch-wide footing and 5-foot-high concrete masonry wall with two or three additional masonry blocks staggered on top of the footing as shown on plate 16. A portion of the channel invert in the vicinity of Valencia Street (sta. 101+60) was paved for parking. The channel formed by the masonry walls and parking area is adequate to control the design floodflow. Photographs shown on pages II-8 through II-9, indicate existing conditions.

2-12 Housing tracts are located on both banks of the creek from the Santa Ana Freeway to the Santa Ana River (channel sta. 10+00), a distance of about 6,400 feet. The creek is capable of conveying the design flow of 5,000 ft^3/s, but its banks are subject to erosion. The flood of 1969 had a peak discharge of approximately 7,000 ft^3/s and did not overtop the channel banks; however, the channel was enlarged by severe bank and invert erosion. The project design flood will result in the flow velocities of 9 to 13 fps.

2-13 Between the Santa Ana Freeway (sta. 75+30 and Flower Street sta. 57+20) bank protection measures by individual property owners predominate and the result is a conglomerate of various types of protection including natural banks, cobblestone, concrete masonry, and concrete walls.

2-14 From Flower Street (sta. 57+20) to Bristol Street (sta. 29+42) the existing trapezoidal channel base width is restricted to about 20 feet with side slopes of approximately 1V on 2H. The slopes are protected by wire-mesh and a growth of ice plant. Many large trees of different varieties such as pine, oak, eucalyptus, sycamore, and cypress are growing along the top of the channel banks.

2-15 Downstream of Bristol Street to the Santa Ana River, a distance of about 1,600 feet, the trapezoidal channel has a base width ranging from 20 to 40 feet and side slopes of 1V on 2H. The side slopes are protected with wire-mesh and a growth of ice plant.

Water Conservation at Gravel Pits

2-16 In early 1986, Orange County Water District (OCWD) acquired the land of the Blue Diamond and Bond pits from Conrock Company. The OCWD will pump water from the Santa Ana River by constructing (construction started January 1988) a 66-inch pipeline to these pits for storage and percolation into the groundwater supply basin. The water conservation project would be initiated prior to the construction of the flood control project; therefore certain features of the existing pits would have to be modified for water conservation. The Water District proposed to: (1) modify the existing steep banks of the pit from 1V on 1H to 1V on 2H by constructing buttress fills to stabilize the existing slope; (2) improve the 21-foot CMP culvert under Villa Park Road by constructing a concrete transition structure, a baffled apron spillway, and a stilling basin for prevention of erosion; and (3) provide a 140-foot wide spillway with a crest elevation at 290 feet for emergency overflow of floodwater from the pits. The spillway would be designed to accommodate a peak outflow of 3,500 ft^3/s. A portion of Santiago Creek downstream of the spillway would be revetted for the anticipated spillway flow. Details of the recommended improvements are presented in the "Design Report for the Santiago Creek Site Improvements" dated February 1986. The report was prepared for Orange County Water District by Lowry and Associates Consulting Engineers.

The Flood Problem

2-17 The flood problem along Santiago Creek can be attributed to the inadequate size of the channel to safely convey the major floods and the high velocity of the flow which causes erosion to the unrevetted banks along the creek. Erosion of banks could allow the creek to change course and could cause severe damage to residential and commercial developments along the creek.

The Authorized Plan

2-18 The authorized flood control plan is described in the Phase I General Design Memorandum on the Santa Ana River Main Stem Including Santiago Creek dated September 1980. The authorized plan consists of (1) detention flood control storage at existing gravel pits located between Villa Park Road and Prospect Street, (2) an outlet structure at Prospect Street, and (3) a riprap trapezoidal channel between the Santa Ana Freeway and the Santa Ana River. The plan recommended in this report is in general accordance with the authorized plan.

The Plan Recommended In This Report

2-19 Based on the need to reduce the peak discharge of floodwater and to prevent bank erosion along the downstream reach of Santiago Creek, the plan recommended in this report is essentially the same as the one authorized by Congress. The plan has been refined to include (1) the latest physical changes of the project, (2) the results of detail design studies, (3) the environmental concerns of various agencies, and (4) criteria established by the local sponsoring agency.

a. In order to reduce the peak discharge along Santiago Creek from Prospect Street to the confluence with Santa Ana River, the outflow from the pits would be controlled and regulated so that the peak discharge would not exceed 3,500 ft^3/s during the 100-year design flood. The existing Blue Diamond and Bond pits between elevations 274 and 298 feet would be utilized for detention of the floodwater. The storage below elevation 274 would be used by the OCWD for water conservation. The existing steep banks of the pits between elevations 170 and 260 feet would be stablized by placing a compacted buttress fill on a 1V on 2H slope against the existing slope. Orange County Water District has proposed to modify the existing slopes up to elevation 230 for water conservation before the construction of the flood control project. The additional modification to the existing slopes from elevation 230 to elevation 260 would be included in the flood control project.

b. The existing creek downstream from the outlet works from the vicinity of Walnut Avenue to the Santa Ana Freeway, a distance of about 5.5 miles, would be unimproved and remain in its existing condition. A floodway would be designated under the guidelines of Federal Emergency Management Agency (FEMA) for the unimproved reach. Hydraulic computations indicate that velocities within this reach of the creek would vary from 3 to 11 feet per second depending on the location, condition, and slope of the creek. The design floodflow would be confined within the existing banks. The local sponsoring agency would be responsible for the floodway management and proper operation and maintenance of this reach of the channel.

c. At the downstream side of the Santa Ana Freeway would begin a 6,400 foot long trapezoidal channel section. This section would be lined with riprap. The invert would have riprap thickness which varies from 12 inches to 21 inches and the side slope thickness would vary from 12 inches to 36 inches. Also, the channel would be lined with a filter blanket which would vary in thickness from 6 inches to 9 inches depending on the thickness of the riprap. The width of the invert varies from 30 feet to 80 feet. Side slopes of 1.75 horizontal to 1 vertical will be required because of right-of-way limitations. The downstream end of the channel would be at the confluence with the Santa Ana River. A transition at the confluence will consist of an 12-inch-thick, 50-foot-long grouted rock apron placed 10 feet below the design invert of the mainstem.

d. The proposed recreation plan would include a 12 foot wide bicycle, hiking, and jogging trail running upstream from Walnut Avenue to Prospect Street on the maintenance access road provided as a part of the basic flood control project. The trail running upstream from Prospect Street to the proposed rest area would be within the project right-of-way on the east side of the Band Pit. The proposed trail rest stop would be developed on the west side of Hewes Road directly adjacent to an as yet unnamed County Regional Park. The rest stop would include an overlook shade structure, drinking fountain, trash receptacles, and appropriate landscaping and signage.

Consideration of Other Alternatives

2-20 Both banks of Santiago Creek from the Santa Ana Freeway to the Santa Ana River have been urbanized and housing tracts have encroached into the floodway. The existing fences mark the location of the property lines indicating that the land available for channel construction varies significantly from one location to the next. The Phase I GDM recommended a channel improvement of 18 inches of riprap on the 1V to 2.5H channel banks and the channel invert, without a maintenance road on top of the channel. Early in the design, OCEMA required consideration of a 20-foot-wide open space be afforded on top of the bank for the operation of maintenance equipment. The existing fence lines and large trees growing on top of channel bank also restrict the space which could be acceptably used for construction and operation of the channel. Investigation of alternative designs for the flood control channel was necessary.

2-21 In addition to the trapezoidal riprap channel cross section as presented in the Phase I GDM, three other designs were considered and evaluated: (1) a trapezoidal concrete channel cross section with a base width varying from 30 to 60 feet, channel heights ranging from 11 to 17 feet, and 1V on 2H side slopes, (2) a composite trapezoidal channel cross section similar to (1) except in areas of restrictive rights-of-way a concrete vertical wall was provided at the top of slope, (3) a trapezoidal riprap channel cross section with a base width varying from 30 to 80 feet, channel heights ranging from 9 to 13.5 feet and 1V on 1.75H side slopes, (4) a concrete rectangular channel, with concrete invert, (5) a concrete rectangular channel with earth invert, (6) a channel with soil cement walls on a 1V on 1H slope, and (7) the 1980 plan without access roads. Based on acceptability to both OCEMA and the local community, the third alternative was considered for implementation. It is similar to the Phase I recommended channel improvement except channel side slopes were steepened to 1V on 1.75 H and riprap was provided to the design water surface (zero freeboard) in entrenched areas to minimize effects on existing fence lines (rights-of-way) and to avoid concrete or grouted stone construction. Where possible freeboard was added in one foot increments on both sides of the channel equally in reaches greater than 400 feet in length if the existing fence lines would not be effected. Access to the channel invert would be through the parking area at Hart Park (shown on pl. 15) and from the invert of the Santa Ana River (shown on pl. 19).

Departures from Authorized Plan

2-22 There are two primary departures from the recommended plan at Santiago Creek. First, the gravel pits at Villa Park and Bond Road have been acquired by the Orange County Water District (OCWD), which will use them for water conservation and flood control. To modify the pits for water conservation, the OCWD will flatten the side slope of the banks. The pits would no longer be available for disposal of excavated material from the Santa Ana River Channel, but flood control storage of approximately 3,500 acre-feet would be still be available as provided in the Phase I GDM, with an additional 1,118 acre-feet of storage needed to control the 100-year flood outflow to 3,500 cfs.

2-23 The second departure from the recommended plan involves the elimination of access roads from the channel improvements at the lower end of Santiago Creek. The existing earth-bottom trapezoidal channel will be enlarged and lined with 18- to 36-inch riprap. This will provide the floodplain with the authorized 100-year flood protection. All operation and maintenance will be assumed by OCEMA; thus OCEMA has assured that emergency maintenance will be done by alternative methods other than conventional maintenance roads. Orange County will be responsible for seeking access agreements across private property to facilitate repair of the channel should damage occur during periods of high flow. Regular maintenance will be accomplished from the channel invert during the dry season.

PHOTO II-1. CHANNEL AT STA. 81+00

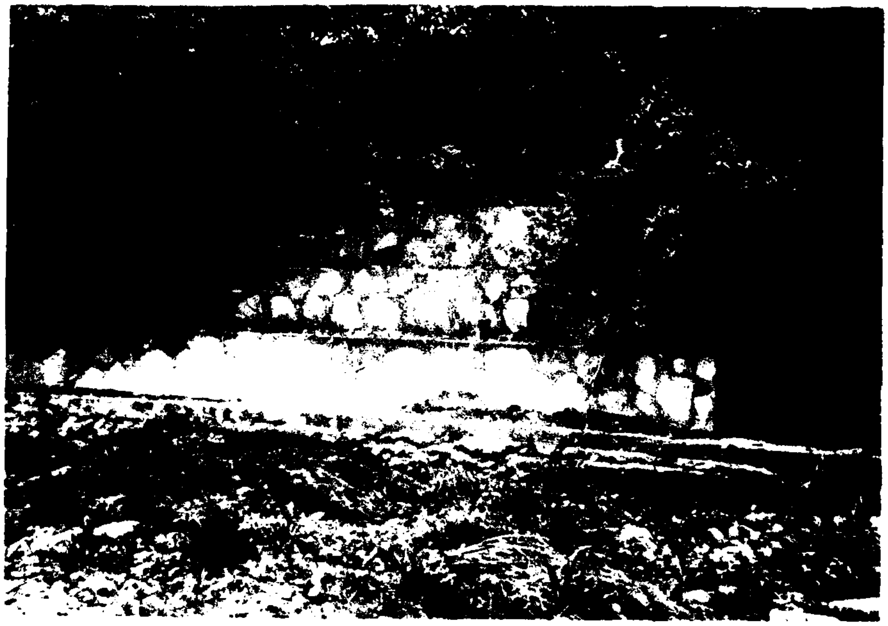


PHOTO II-2 BLOCK WALL AT STA. 90+00

PHOTO II-3 CHANNEL AT STA. 125+00
SHOWING GARDEN GROVE FWY.

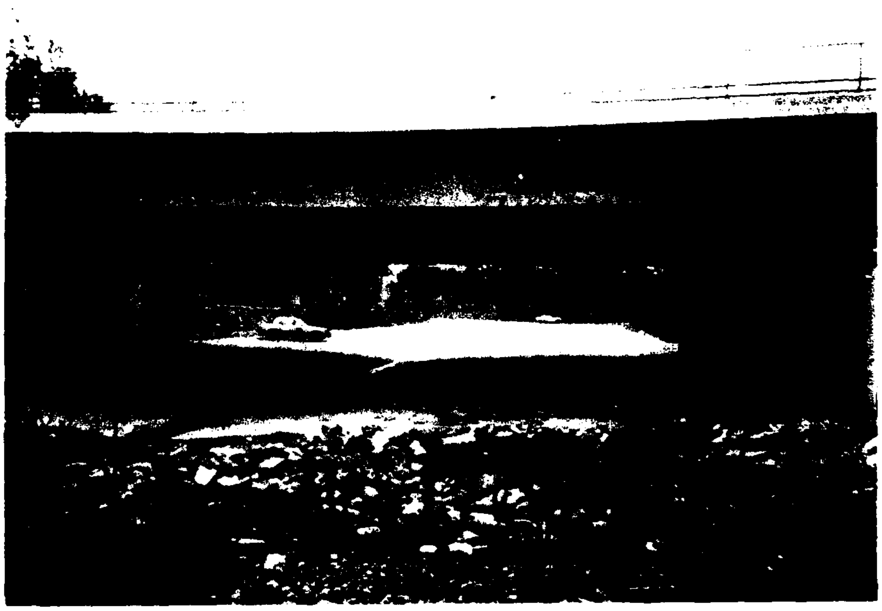


PHOTO II-4. CHANNEL AT STA. 134+00

III. HYDROLOGY

Introduction

3-01 This section presents a brief description of the Santiago Creek drainage basin and presents design discharges for the recommended Santiago Creek improvements. More detailed information on the development of the hydrology is given in Volume 7 of the Phase II General Design Memorandum for the Santa Ana River Mainstem including Santiago Creek.

General

3-02 Santiago Creek drains approximately 102 mi^2. Most of the watershed is within Orange County, with a small portion of the headwaters in Riverside County. It flows southwest through the Cities of Orange and Santa Ana into the Santa Ana River. Elevations in the basin range from 110 feet at the confluence with the Santa Ana River to 5687 feet at Santiago Peak in the Santa Ana Mountains. Stream gradients range from 25 feet per mile in the lower reaches of Santiago Creek to 305 feet per mile in the upper reaches.

3-03 The watershed climate is semiarid, characterized by moderate precipitation in the winter and little or no precipitation in the summer. Precipitation in the watershed is nearly all in the form of rain and snow is not considered an important contributory factor to runoff in Santiago Creek. Typically, most of the rainfall occurs during the 4-month period from December through March. Rainless periods of several months in the summer are not uncommon. The mean annual rainfall over the watershed is approximately 18 inches, with ranges from 12 inches near the Santa Ana River to 28 inches in the higher mountain areas. Runoff in the basin is erratic with almost no flow for several months at a time. Climatic and drainage area characteristics are not conducive to continuous flow and little or no streamflow occurs, except during and immediately after rain.

3-04 The watershed of Santiago Creek contains a major water supply reservoir, a flood control dam, and gravel pits, all of which influence flood runoff. The gravel pits (Blue Diamond - Bond Pits) are being developed by local interests as a groundwater recharge basin. The upper part of the storage allocation in the gravel pits will be reserved for flood control purposes as part of this project. The drainage area above Villa Park Dam is approximately 83.8 mi^2 and is expected to remain largely undeveloped during the project life. Downstream from Villa Park Dam, the foothills and the alluvial plain are presently partially urbanized and are expected to be completely urbanized by the end of the project life. Figure 1 shows the project location and the Santiago Creek drainage area.

Design Flood Peak Discharges

3-05 The recommended plan for Santiago Creek provides 100-year flood protection for the residents of the Santiago Creek floodplain. The recommended improvements include constructing flood control gates at the outlet of the gravel pits and making downstream channel improvements to pass the 100-year design discharge of 5,000 ft^3/s. The operation plan of the outlet would match outflow equal to inflow up to a controlled maximum release of 3,500 ft^3/s. The pits would store the volume of uncontrolled spillway flow (5,640 ft^3/s) from Villa Park Dam. This routing is shown in figure 2. Contemporaneous runoff from the area downstream from the pits, added to the outflow, results in a peak discharge of 5,000 ft^3/s at the Santa Ana River. The 100-year design discharges are shown in figure 3 and listed in table III-1.

Table III-1. Design Flood Peak Discharges along the Santiago Creek Channel.

Concentration Point	Subarea Name	Drainage Area Contributed (mi^2)	Design Discharge (ft^3/sec)
Santiago Reservoir Basin at Santiago Dam	A	63.40	
Villa Park Dam Outflow	A, B	83.80	5,600
Handy Creek at upstream of Jamestown Way	C	2.90	820
Santiago Creek at Villa Park Road	A, B, C, D	91.40	5,600
Pits Outflow at at Prospect Avenue	A, B, C, D, D, E	94.59	3,500
Walnut Avenue			3,700
Chapman Avenue	A, B, C, D, D, E, F	96.98	3,900
Tustin Avenue			4,200
Garden Grove Freeway	A, B, C, D, D, E, F, G	101.02	4,500
Santa Ana Freeway			4,700
Confluence with Santa Ana River	A, B, C, D, D, E, F, G, H	102.70	5,000

IV. HYDRAULIC DESIGN

General

PROJECT DESCRIPTION

4-01 The authorized flood control project for Santiago Creek will consist basically of a below-grade reservoir formed by abandoned gravel pits between Villa Park Road and Prospect Street, a gated outlet structure at Prospect Street, an improved outlet channel from Prospect Street approximately 4,000 feet downstream to Walnut Avenue, and channel stabilization for approximately 6,400 feet from the Santa Ana Freeway to the Santa Ana River. The project described herein follows the plan authorized in the Phase I General Design Memorandum with the following exceptions: (1) the inlet structure at Villa Park Road has been eliminated; (2) the automatic constant-level gates will be replaced by radial gates; (3) a single transferable bulkhead gate will be provided for maintenance of the service gates; (4) an overflow structure will be provided to insure that the location of flooding downstream of the project does not change when the design flood is exceeded; and (5) the channel cross section between the Santa Ana Freeway and the Santa Ana River has been modified. Further discussion of these exceptions is provided herein.

GENERAL DESIGN CRITERIA

4-02 The hydraulic design of the project was prepared following general guidance in EM 1110-2-1601 "Hydraulic Design of Flood Control Channels," EM 1110-2-1602 "Hydraulic Design of Reservoir Outlet Works," ETL 1110-2-120 "Additional Guidance for Riprap Channel Protection," applicable Hydraulic Design Charts, and other accepted references as noted herein. Specific hydraulic design criteria for this project is to control the 100-year flood by reducing the peak inflow of 5,600 ft^3/s to 3,500 ft^3/s, which is the maximum non-damaging discharge of the existing channel. The outlet structure must pass all inflows up to 3,500 ft^3/s, and regulate the outflow to 3,500 ft^3/s for all pool levels in the pits between elevations 280 and 298. The outlet structure must provide reasonable flow regulation if one service gate is inoperative in the closed position. Since there are no appreciable physical or economic constraints to force the hydraulic design to depart from established general design criteria, verification of the design by physcial model studies is deemed unnecessary.

ALTERNATIVE DESIGN

4-03 A conceptual design of various alternatives for the outlet structure was conducted. Preliminary designs were prepared for outlet structures with sill elevations at, below, and above the sill elevation used in the Phase I GDM, each structure with three service gates, and for an outlet structure at the same sill elevation with four service gates. All designs were prepared to fully satisfy the established design criteria with one gate assumed inoperative in the closed position. It was determined that the least costly of the above alternatives would be an outlet structure at the same sill elevation considered in the Phase I GDM, with three service gates.

4-04 After final design of the three-gate outlet structure was completed, the possibility of eliminating one of the three gates and gate passages was investigated. The investigation was made in accordance with guidance in EM 110-2-1602, paragraph 3-12a. This guidance requires that, for reservoir outlet flows requiring regulation, "two or more gate passages be provided, such that if one passage is inoperative, a reasonable flow regulation as pertains to project purposes can be obtained." Consequently, backwater computations were made through the outlet structure for the three-gate design assuming two gates inoperative in the closed position, and a rating curve was established. The design flood as well as lesser floods were then routed through the outlet structure and overflow structure. With only one gate operative, the following increases in the 100-year design discharge would occur downstream: at Prospect Street, 31 percent; at the Newport Freeway, 17 percent; at the Garden Grove Freeway, 2 percent; at the Santa Ana River, 0 percent. In addition, a single gate could satisfy the design criteria of controlling the outflow to a maximum of 3,500 ft^3/s and the pool elevation to a maximum of 298 feet NGVD for up to a 95-year flood. From the above results, it was concluded that a two-gate structure can provide a reasonable level of protection in the unlikely event that one gate passage is unavailable for flow regulation. Consequently, the third gate and gate passage were eliminated from the outlet structure.

Inlet Structure

GENERAL

4-05 Under existing conditions, flows enter the gravel pits through a 21-foot diameter, 333-foot long corrugated metal pipe under Villa Park Road. The plan approved in the Phase I General Design Memorandum called for replacing this pipe with a clear span bridge and an inlet chute with baffle blocks. The chute would extend down the side of the road embankment approximately 74 feet to the bottom of the pits. At the time the Phase I GDM was prepared, the pits had been abandoned by the owner.

It was likely that the water surface in the pits could be relatively low at the beginning of a major flood; hence, the Phase I plan called for an inlet structure that would dissipate the energy of the inflow as it passed down the embankment of Villa Park Road.

4-06 Subsequent to the time the Phase I report was prepared, the pits have been acquired by the Orange County Water District. This agency plans to use the pits as a water conservation facility and store water during the flood season, up to elevation 274. Any modification of the inlet would be required for either the water conservation project or for protection of Villa Park Road and is not required as a result of the flood control project. A deep pool will exist when the outlet gates are in operation for flood control. The hydraulic capacity of the existing pipe under Villa Park Road was analyzed to determine if the pipe could convey the design flood inflow without effecting the flood control project.

ANALYSIS

4-07 Hydraulic rating curves of upstream water surface elevation versus discharge were prepared for tailwater elevations of 280, 285, 290, 295, and 298. Inlet control and outlet control computations were prepared. For inlet control, the orifice equation was used with a value of 0.6 for the discharge coefficient C. This value corresponds to a sharp-edged entrance, which was assumed to achieve a conservatively low estimate for discharge. For outlet control, a value of 0.7 for the intake loss coefficient K_e was used, and a Manning's "n" value of 0.024 was used for friction losses.

4-08 Because of the high submergence the control will be at the outlet for all tailwater elevations investigated. The resulting rating curves are displayed in figure 4. Since the tailwater elevation varies during the design flood, the headwater elevation was computed using the Corps of Engineers Interior Drainage Flood Routing computer program. The tailwater elevation versus time relation was taken from a hydrologic flood routing of the design flood hydrograph assuming all inflow reaches the pits unimpeded. It was determined that the maximum headwater elevation will be 303.3 feet, which is 2.2 feet below the low point of Villa Park Road.

4-09 Based on this analysis, the existing pipe inlet has sufficient capacity to admit the design flood without overtopping the Villa Park Road embankment. Even if the pipe were to become partially clogged and cause overtopping of the road embankment, none of the inflow could flank the pits because of surrounding high ground. Also, no flow surge will result from overtopping and failure of the road embankment because the storage available in the pits is much greater than the limited storage upstream of the road. No additional features will be required at the inlet for the satisfactory operation of the flood control project.

Outlet Structure

GENERAL

4-10 The outlet structure will consist of a trash strut, a covered entrance chamber with two sets of gate slots for emergency closure by means of a single transferable bulkhead gate, an open gate chamber with two radial gates for flow regulation, a parabolic approach chute, a stilling basin with baffle blocks and end sill, and an exit transition with an adverse-sloping apron (pls. 5 through 8).

TRASH STRUT

General

4-11 The trash strut (pls. 7, and 8) is designed to trap all debris large enough to damage or clog the outlet, yet still provide minimum resistance to flow. The trash strut will be in the form of a half hexagon in plan view and will consist basically of vertical concrete beams 1 foot wide and horizontal concrete struts 2 feet wide. The edges of all members will be streamlined with a semi-circular shape to minimize resistance to flow. The strut will be 32.5 feet high by 70 feet wide. The outside top of the strut will be at elevation 300 feet, 2 feet above the maximum pool level. The strut will provide 48 openings, each 6 feet high by 5.25 feet wide. To facilitate removal of trash, the strut will have a batter of 10 vertical on 1 horizontal and the roof across the strut and entrance chamber will be structurally designed to support heavy equipment.

Design Criteria

4-12 Following guidance in EM 1110-2-1602, the vertical and horizontal openings of the trash strut were set to be less than two-thirds of the gate height and width, respectively. The total net area will be 820 ft^2, which is the minimum required to keep the energy loss through the strut to an acceptable level. If this area were to be reduced by 50 percent because of trash accumulation, the average velocity through the strut would be 8.8 ft/s at the design release of 3,500 ft^3/s at the minimum pool elevation of 280 feet. This velocity is well below the maximum velocity of 15 fps recommended in EM 1110-2-1602.

Energy Losses

4-13 Equation 2-12 in EM 1110-2-1602 was used to determine energy losses through the trash struts. For capacity computations, the strut was assumed 50 percent clogged. For this condition, a loss coefficient K value of 1.18 was calculated using Equation 11, p. 472, "Design of Small Dams," U.S. Bureau of Reclamation. For velocity computations for the design of the stilling basin, the energy loss through the strut was assumed zero to achieve a conservatively high velocity.

ENTRANCE CHAMBER

General

4-14 The entrance chamber containing the gate slots for a single transferable bulkhead gate will be covered to provide maintenance access for the trash strut, slide gates, and radial gates. The upstream edge of the chamber will coincide with the trash strut, and the downstream edge will coincide with the intake headwall. The length of the chamber will vary from 14.5 to 42 feet, which will allow ample access to the slide gate operators and for maintenance vehicles. The invert will be level at elevation 267.5. For energy losses at the gate slots, a loss coefficient K value of 0.01 was used for capacity computations, as recommended in EM 1110-2-1602. For friction losses, a Manning's "n" value of 0.016 was used. For velocity computations, both losses were neglected.

Vortex Control

4-15 Vortices can increase the propensity of debris clogging the trash strut and thus should be avoided. The design of the outlet was checked for the formation of vortices using criteria in EM 1110-2-1602. Since the design is symmetrical, the design curve on plate C-35 for symmetrical approaches was used. It was determined that the intake will be vortex-free for pool elevations between 290 and 298. During the design flood, the pool will be in this range for 85 percent of the total duration of the event. To minimize the possibility of vortices for the remaining 15 percent of the duration of the design event, an anti-vortex plate will be provided. The plate will extend across the entire width of the entrance chamber at elevation 274. The plate will consist of a steel grating 3.7 feet wide by 2 inches high with openings 1 foot square. The plate will suppress the formation of vortices by creating flow resistance to eddy currents. The design of the plate was based on the results of a hydraulic model study of a similar device used in a junction structure of a large sanitary sewer outfall; the design is documented in the Colorado State University report "Hydraulic Model Study of South West Ocean Outfall Distribution Box," by D.B. Simons et al., March 1978.

GATE CHAMBER

General

4-16 The chamber containing the radial gates for flow control will be open to the atmosphere and will be divided into two separate smaller chambers. Each radial gate will be 20 feet wide and 12 feet high. The minimum height of the intake conduit at the entrance will be 12 feet. The maximum gate opening for controlled releases will be 10 feet to assure flow control at the gate lip. The roof and pier noses at the entrance will be streamlined with simple elliptical curves following guidance in EM 1110-2-1602, paragraph 3-6c and plate C-22. The invert will be level at elevation 267.5. The length of the chamber will be 22 feet.

Energy Losses

4-17 Discharge coefficients for the radial gates were determined from Plate C-24 of EM 1110-2-1602. Flow through the radial gates will remain unsubmerged by tailwater for the design discharge at all pool elevations between 280 and 298 feet. The contraction coefficient was calculated using Equation 6-43, in Open Channel Flow, by Henderson. The contraction coefficient was used to calculate the depth and velocity of the vena contracta immediately downstream of the gates. This procedure inherently includes the energy loss through the radial gates from the water surface in the covered gate chamber immediately upstream. For free-flow conditions at the gate, the discharge coefficients will range from 0.67 to 0.74, and contraction coefficients will vary from 0.78 to 0.98. The energy loss from the entrance chamber to the radial gates was determined using plate C-22 in EM-1110-2-1602. The pressure drop coefficient "C" was taken as the head loss coefficient "K", and the maximum value of 1.1 was used.

Gate Rating Curve

4-18 A rating curve for various openings of one radial service gate for the minimum pool elevation of 280 feet is displayed in figure 5. The curve is based on 50 percent clogging of the trash strut and maximum energy losses. A complete family of rating curves for various pool elevations and gate openings will be prepared later for the water control manual for the project. To more closely approximate typical operating conditions, the trash strut will be assumed 25 percent clogged, and average values of energy loss coefficients will be used.

STILLING BASIN

General

4-19 The stilling basin will ensure the formation of a stable hydraulic jump through which the high energy of the jet under the radial gates can be safely dissipated. The stilling basin configuration is displayed on plate 7. The basin will feature a parabolic approach chute from the radial gate chamber, a depressed invert with baffle blocks and end sill, and a transition with a adverse-sloping exit apron. The transition will join the two separate chambers of the stilling basin to the concrete outlet channel.

4-20 The length of the parabolic approach chute will be 33 feet. The upstream and downstream invert elevations will be 267.5 and 260 feet, respectively. The upstream and downstream wall heights will be 14 and 17 feet, respectively. The length of the stilling basin proper will be 45 feet from the parabolic chute to the end sill. The invert of the basin will be level at 260, and the wall height will be a constant 17 feet. The length of the transition will be 78 feet. The upstream and downstream invert elevations of the transition will be 260.5 and 265.2, respectively. The wall height will vary from 17 feet at the upstream end to 10 feet at the downstream end. The parabolic chute and stilling basin will be divided into two chambers, each 20 feet wide, separated by divider walls 2 feet thick. The upstream and downstream widths of the transition will be 42 and 47 feet, respectively. The divider walls will extend 20 feet into the upstream end of the transition.

4-21 Each chamber of the stilling basin will contain two rows of baffle blocks spaced 2 feet apart and an end sill. Each block will be 2 feet high, 1 foot wide at the top, and have a 45-degree slope on the downstream face. The first row of blocks will be located 22 feet downstream of the parabolic chute. The second row of blocks will be located 7.5 feet downstream from the first row, with the blocks staggered between the upstream blocks. The end sill located 15.5 feet downstream from the second row of block will be 1 foot high, 0.5 feet wide at the top, and have a 45-degree slope on the upstream face.

Design Criteria

4-22 The stilling basin was designed following guidance in EM 1110-2-1602, Chapter 5 and Appendix F. The controlling design condition for the basin is the design release of 3,500 ft^3/s at the maximum pool elevation of 298. This condition will generate the strongest hydraulic jump. The design was evaluated for other flow conditions to ensure that the hydraulic jump will be contained within the basin. The upstream sequent depth of the jump was calculated by neglecting energy losses between the radial gate and the basin to achieve a conservatively high estimate of incoming velocity. The elevation of the invert of the basin was determined by trial such that the tailwater depth will be 0.85 of the sequent depth d_2 of the jump. The tailwater depth was calculated with backwater computations for the outlet channel, as discussed below. The top of the outer stilling basin walls will be at elevation 277 to provide 2.3 feet of the freeboard above the maximum d_2 depth.

4-23 As indicated above, one design objective of the stilling basin is to ensure that the hydraulic jump is contained within the basin for all flow conditions. The controlling case for the design of the basin is the maximum operating level of 298. For the minimum operating level of 280, the hydraulic jump will be submerged and thus will not sweep out of the basin. For operating elevations between 280 and 298 and the design release of 3,500 ft^3/s, the Froude Numbers range from 2.95 to 5.22. Undesirable undular jumps occur only for Froude Numbers less than 1.7, and thus will not present a problem for the design release. However, an undular jump could form for a release less than 3,500 ft^3/s, and the corresponding wavy water surface could overtop the walls of the stilling basin. To check for this possibility, the height of the first wave of an undular jump was determined using plate 47 of EM 1110-2-1601. The computations indicated that the maximum depth of an undular jump will be less than the corresponding tailwater elevation, so that any undular jump will be submerged. Also, the length of any undular jump was determined using figure 15-04, in Open Channel Hydraulics, by Chow, and was found to be less than the length of the stilling basin. As a result, the hydraulic jump will be contained within the stilling basin for the full range of operating conditions.

4-24 The invert profile of the parabolic approach chute was computed using Equation 5-3, EM 1110-2-1602. The transition was designed following guidance in EM 1110-2-1601, paragraph 10. The flare angle for the transition walls will be 1.8 degrees, which is well below the maximum recommended value of 6 degrees. The divider walls in the stilling basin will extend 20 feet into the exit apron to minimize disturbance when the separate flows combine, yet still minimize encroachment in the transition.

Energy Losses

4-25 For capacity computations at the maximum pool elevation, the energy loss through the hydraulic jump was computed using Equation 3-24 (Chow). Friction losses through the parabolic chute and transition were computed with a Manning's "n" value of 0.016. For the stilling basin, the friction loss was included, and a Manning's "n" value of 0.04 was used to account for the roughness provided by the baffle blocks and end sill. For the transition, the expansion loss was computed using an expansion coefficient of 0.3. For capacity computations at the minimum pool elevation, the energy loss through the hydraulic jump was neglected since the jump will be submerged by the tailwater.

SUMMARY OF HYDRAULIC ELEMENTS

4-26 A summary of hydraulic elements through the outlet structure is presented in table IV-1. Elements are shown for the minimum pool elevation of 280 feet, for which maximum energy losses were considered, and also for the maximum pool elevation of 298 feet, for which mimimum energy losses were considered.

RATING CURVE WITH GATES WIDE OPEN

4-27 A rating curve for the outlet structure for open channel flow conditions with both service gates wide open is displayed in figure 6. The curve was prepared using backwater computations from the downstream end of the stilling basin to the reservoir pool. The Los Angeles District computer program WASURO was used to calculate the water surface. Maximum energy losses were considered for both the outlet structure, as explained in paragraphs 4-13, 4-14, and 4-25 and also for the outlet channel, as explained in paragraphs 4-29, 4-30, and 4-33. It was determined that critical depth control will prevail just downstream of the crest of the parabolic approach chute for the entire range of operating discharges. The rating curve was utilized to route the design flood through the reservoir. The routing of the design flood is discussed in this design memorandum in Volume 7, Hydrology.

Table IV-1. Summary of Hydraulic Elements for Outlet Structure.

Hydraulic Element	Pool Elevation 280 Ft	Pool Elevation 298 Ft
Maximum Discharge (total)	3,500 ft^3/sec	3,500 ft^3/sec
Radial Gate Opening	10 ft	3.1 ft
Depth at Vena Contracta	9.8 ft	2.3 ft
Velocity at Vena Contracta	8.9 ft/s	38.7 ft/s
Depth at Toe of Parabolic Drop	12.5 ft	2.0 ft
Velocity at Toe of Parabolic Drop	7.0 ft/s	44.9 ft/s
Depth at U/S End of Stilling Basin	12.5 ft	14.7 ft
Velocity of U/S End of Stilling Basin	7.0 ft/s	6.0 ft/s
Depth at D/S End of Stilling Basin	12.5 ft	12.5 ft
Velocity at D/S End of Stilling Basin	7.0 ft/s	7.0 ft/s
Depth at End of Transition	7.4 ft	7.4 ft
Velocity at End of Transition	11.9 ft/s	11.9 ft/s

Outlet Channel

GENERAL

4-28 The outlet channel (pls. 7, 10, and 11) will begin at the downstream end of the exit apron of the stilling basin. The first 200 feet will consist of a rectangular concrete channel under Prospect Street. Immediately downstream will be a 300-foot long concrete transition, rectangular at the upstream end and trapezoidal at the downstream end. Downstream of the transition, a trapezoidal channel revetted with riprap on the sides and invert will extend approximately 4,000 feet downstream to a point of daylighting with the existing natural channel near Walnut Avenue. The improved channel will join the natural channel with a 100-foot long transition.

RECTANGULAR CHANNEL

4-29 The rectangular concrete channel will have a bottom width of 47 feet, a wall height of 11 feet, a single pier one foot wide, and an invert slope of 0.003. The water surface for the design discharge of 3,500 ft^3/s was computed with the WASURO computer program. Following guidance in EM 1110-2-1601, a relative roughness "k" value of 0.007 feet was used for capacity computations. The corresponding Manning's roughness coefficient "n" is 0.016. Since the trash strut was designed to trap only large debris, an allowance of 2 feet of debris on each side of the pier was made. The flow state will be stable subcritical, with the depth more than 10 percent greater than critical depth. Class A flow will prevail at the upstream end of the pier. The freeboard will range from 2.3 to 2.7 feet, which exceeds the minimum value of 2.0 feet recommended in EM 1110-2-1601.

TRANSITION

4-30 The transition from the rectangular concrete channel to the riprap-lined trapezoidal channel will be the warped type, with vertical sides at the upstream end and sloping sides of 2 horizontal to 1 vertical at the downstream end. The transition will be 300 feet long, have upstream and downstream bottom widths of 40 and 30 feet, respectively, upstream and downstream wall heights of 10 and 12.5 feet, respectively, and an invert slope of 0.003. The transition was designed in accordance with EM 1110-2-1601, paragraph 10 and plate 20. The wall flare angle was set at 5 degrees, which is less than the recommended maximum of 6 degrees. The water surface was computed as discussed in paragraph b., above. An expansion loss coefficient of 0.3 was used to compute expansion losses. Freeboard will vary from 2.5 to 3.6 feet, which equals or exceeds the minimum value of 2.5 feet recommended in EM 1110-2-1601 for trapezoidal channels.

TRAPEZOIDAL CHANNEL

4-31 The trapezoidal channel will have a bottom width of 30 feet, depth of 12.5 feet, invert slope of 0.0024, and side slopes of 2 horizontal to 1 vertical. The channel will feature a special transition at the abandoned railroad bridge, which would enable the bridge to remain in place and avoid the cost of removal. The transition is displayed on plate 9. The special transition will be required to protect the bridge piers from the excavation required for the channel.

4-32 The design discharges in Vol. 7, Hydrology, were utilized in a manner such that the channel will not be overtaxed by potential future side drains constructed upstream of the concentration points used in the design hydrology. Specifically, design discharges at concentration points were used for the reach of channel upstream and prorated accordingly. Consequently, the design discharge is 3,700 ft^3/s from the upstream end of the channel to the railroad bridge, and 3,900 ft^3/s downstream. The design water surface was computed with the HEC-2 program, starting in the existing natural channel further downstream at Chapman Avenue. The roughness coefficient was determined during the design of the riprap.

4-33 The riprap was designed following guidance in EM 1110-2-1601 and ETL 1110-2-120. An initial trial value of roughness coefficient was assumed and a trial water surface was computed. An initial trial riprap thickness and gradation were then assumed. An initial value of relative roughness "k" was taken as the minimum value of the median rock diameter, and a corresponding Manning's "n" value was determined using plate IV-04 in EM 1110-2-1601. The water surface profile was re-computed, and the riprap design was adjusted as required. The process was repeated until the difference between the trial and final "n" value was negligible. Then, the design water surface was recomputed using a roughness coefficient based on the maximum value of the median rock diameter for the adopted riprap design. The final roughness coefficients are 0.029 for riprap design and 0.030 for channel depth.

The flow state will be stable subcritical. Average flow velocities will range from 6.9 to 8.5 fps. The riprap layer thickness will be 12 inches, and the median rock diameter will be 8 inches for both the sides and invert for the entire length. The above values correspond to a specific weight of rock of 165 pcf. Freeboard will vary from 2.6 to 3.3 feet.

4-34 The horizontal alignment of the channel will include three simple curves, each with a radius of 1,000 feet. The superelevation of the water surface at these curves was computed with Equation 26 in EM 1110-2-1601 and was found to range from 0.1 to 0.2 feet. Guidance in EM 1110-2-1601 indicates that superelevation values of less than 0.5 feet can be accommodated with normal freeboard. Consequently, no increase in channel depth will be required at the curves.

4-35 Losses at the special transition were calculated using the normal bridge routine in the HEC-2 program. Two feet of debris was assumed on each side of each pier.

4-36 The trapezoidal channel will meet the existing natural channel with a simple transition. The transition will be graded to form a smooth connection to the existing cross section and will be revetted with 18 inches of grouted rock. A 10-foot-deep, 18-inch-thick grouted rock cutoff wall will be provided at the downstream end to protect the trapezoidal channel from possible degradation of the natural channel.

Overflow Structure

GENERAL

4-37 Because the flood control project for Santiago Creek features a below-grade reservoir created by abandoned gravel pits, there will be no loss of reservoir when the design flood is exceeded. However, it is important that the project not worsen downstream flooding by altering flow paths when the design flood is exceeded. To satisfy this objective, an overflow structure will be provided (pls. 5 and 9). The structure will be located along the left bank of the existing channel of Santiago Creek upstream of Prospect Street. The overflow structure will consist of a simple 12-foot-wide broad-crested weir, 420 feet long, with the crest set at the maximum pool elevation of 298 feet. Since the minimum ground elevation along the downstream rim of the pits is 300 feet, the overflow structure will provide 2 feet of freeboard for the design flood. The upstream and downstream sides of the structure, as well as the invert and right bank of the creek channel, will be protected from erosion with an 18-inch-thick layer of grouted rock.

DESIGN CRITERIA

4-38 Data for existing, without project overflow conditions was taken from Flood Plain Information Report - Lower Santiago Creek, published by the Los Angeles District in 1973. The report indicates that overflow will first occur along the existing creek alignment until the water surface in the pits reaches elevation 300 feet. At that elevation, water will begin to overflow the pits at the corner of Prospect Street and Bond Avenue. Overflow at this location will continue to the south and southeast, inundate a large area, and never return to Santiago Creek. As a result, it was determined that the project must ensure that when the design flood is exceeded the flood discharge along Santiago Creek is the same as for existing conditions until the water surface in the pits exceeds elevation 300 feet. In order to ensure that all of the flow over the overflow structure reaches the existing Santiago Creek channel, the ground surrounding the outlet works will be filled to elevation 300 feet.

DESIGN PROCEDURE

4-39 In order to determine the appropriate design discharge for the overflow structure, water surface computations were made for the existing Santiago Creek channel from Chapman Avenue to the gravel pits for a range of discharges. The computations were made with the HEC-2 program. Values of Manning's roughness coefficient were determined using Cowan's Method as described in Open Channel Hydraulics (Chow). Vegetation in the channel was assumed to remain in place. The resulting "n" values were determined to be 0.03 for the channel and 0.04 for the overbanks. The Prospect Street culverts were assumed to remain intact. When the water surface in the pits is at elevation 300 feet, approximately 7,000 ft^3/s will flow down Santiago Creek. To maximize reliability of operation when the design flood is exceeded, it was determined that the opening for the service gates will remain at the setting for the maximum operating pool elevation of 298 feet for all higher pool elevations. Accordingly, the overflow structure was designed for a discharge of 3,500 ft^3/s, which is equal to the difference of 7,000 ft^3/s and the design discharge of 3,500 ft^3/s through the outlet structure.

4-40 The discharge coefficient was determined following guidance in the Hydrologic Engineering Center publication Volume 6 - Water Surface Profiles. Figure 4-02 was used to determine the base discharge coefficient, and figure 4-03 was used to determine the correction for submergence. For the design condition, the tailwater will submerge the crest of the overflow structure by 1.4 feet. The resulting discharge coefficient was determined to be 2.96. The rating curve for the overflow structure is displayed in figure 7.

Channel from Walnut Avenue to Santa Ana Freeway

GENERAL

4-41 As indicated in the Phase I General Design Memorandum, most of the reach of Santiago Creek from Walnut Avenue to the Santa Ana Freeway has been improved by local interests and has sufficient capacity to convey the design flood. As part of the final design of this project, the capacity of the channel was verified with backwater computations. Hydraulic elements, freeboard values, profiles of the design flood water surface, the invert, and both banks, as well as overflow boundaries, are displayed on plates 11 through 17. It was determined that the existing channel will in fact contain the design flood throughout the entire reach, except for some minor inundation confined close to the channel in an undeveloped area on the left bank between stations 103+00 and 99+80.

ANALYSIS

4-42 Backwater computations were made with the HEC-2 computer program. Channel geometry was taken from topographic mapping at a scale of 1 inch to 100 feet, compiled from aerial photography flown in 1983. Bridge geometry was taken from back-up data for the 1973 Flood Plain Information Report. Additional channel and bridge geometry was taken from field reconnaissance to verify and update the data as required. Two feet of debris was assumed on each side of each pier at all bridges. Values of Manning's roughness coefficient "n" were estimated using Cowan's method. Values ranged from 0.018 in reaches of cobblestone invert and walls to 0.05 in reaches of earth invert and banks with considerable vegetation. Design discharges were developed as described in paragraph 4-32.

EROSION

4-43 Flow velocities for the design flood were determined to range from 3 to 14 ft/s, with an average of 8 ft/s. Average flow velocities exceeding 6 ft/s are generally erosive. However, channel erosion is difficult to quantify analytically. Consequently, local interests were queried about the history of erosion in this reach. It was found that even during the flood of February 1969, which was the flood of record and was larger than the design flood, erosion of the streambanks was relatively minor. The only location where erosion damage was significant was at the Cambridge Street bridge. As a result, it was concluded that this reach can remain unimproved with no further improvement and still convey the design flood with minimal inundation or erosion damage.

Channel Stabilization from the Santa Ana Freeway to the Santa Ana River

GENERAL

4-44 As indicated in the Phase I GDM, the reach of Santiago Creek from the Santa Ana Freeway to the Santa Ana River has historically suffered significant erosion and thus will require stabilization for safe operation of the project. The conceptual plan authorized in the Phase I report called for stabilization of this reach with an 18-inch-thick layer of riprap, with minimal modification of the existing channel geometry.

DESIGN PROCEDURE

4-45 The design of the riprap followed the same procedure as for the trapezoidal outlet channel, as explained in paragraph 4-33, except that the WASURO program was used to compute the water surface. Design discharges were developed as described in para. 4-32. The design discharge for this reach is 5,000 ft^3/s. At the confluence with the Santa Ana River, the design water surface is controlled by the peak flow of 46,000 ft^3/s in the Santa Ana River downstream from the confluence with the coincident discharge of 4,000 ft^3/s in Santiago Creek. Roughness coefficients for riprap design varied from 0.029 to 0.033. For channel depth, the roughness coefficients varied from 0.030 to 0.038, with an average value of 0.033. The final water surface for channel depth was computed using a constant value of 0.035.

STABILIZATION FEATURES

4-46 The channel stabilization, as shown on plates 17 through 20, will result in a trapezoidal channel cross section with bottom widths ranging from 30 to 80 feet and depths ranging from 8.5 to 12.5 feet. Side slopes of 1.75 horizontal to 1 vertical will be required because of right-of-way limitations. The invert will be graded into three reaches with slopes of 0.004891, 0.005230, and 0.004566. A composite section with vertical walls 6.5 feet high will be provided in a 65-foot long reach through the pedestrian bridge just upstream of Bristol Street. The composite section is required to minimize the backwater effect of the piers and to keep the flow regime stable. Velocities based on minimum roughness coefficients, will range from 9.0 to 12.9 ft/s. A summary of hydraulic elements is provided on plate 21. The stabilized channel will convey the design discharge below the existing ground at the right-of-way line, although freeboard in many locations will be less than the minimum of 2.5 feet recommended in EM 1110-2-1601.

4-47 Riprap thickness will vary from 12 inches on both the sides and invert to 36 inches on the sides and 21 inches on the invert. The variation of the riprap thickness and median rock diameter along the stabilization reach is shown on plate 21. For much of the reach, it will not be possible to place riprap above the design water surface because of right-of-way constraints. However, where sufficient right-of-way is available, the top of the riprap was set up to a maximum of 2 feet above the design water surface, with consideration given to practical construction by adhering to the following criteria: (1) no interference with existing fence lines; (2) the same top of riprap elevation for both sides of the channel; (3) minimum increments of one foot above the water surface; and (4) increments constant for a minimum length of 400 feet along the channel.

4-48 The channel stabilization will join the channel improvements for the Santa Ana River with a simple transition. The grade control structure that will be constructed in the Santa Ana River just downstream of the confluence will control general degradation of the mainstem and thus will prevent headcutting in the stabilized reach of

Santiago Creek. Protection from possible local scour at the downstream end of the stabilization will be prevented by an 18-inch-thick, 10-foot-deep grouted rock apron.

Sedimentation

4-49 The design of the flood control project for Santiago Creek will inherently prevent any adverse sedimentation impacts. Deposition of sediment in the channel downstream of the outlet structure will be prevented because all of the inflowing bed material load will be deposited in the deep pool in the pits. Scour of the downstream channel invert and erosion of the channel banks will be prevented by the riprap revetment in the outlet channel and in the stabilized reach downstream of the Santa Ana Freeway. Significant erosion has not occurred historically in the reach of the channel that will remain unimproved, even for flows larger than the design flood, as noted in paragraph 4-42 above. Headcutting in the two reaches of channel improvement will be prevented by the cutoff wall at the end of the outlet channel and by the grade stabilization that will be constructed for the Santa Ana River at the confluence with Santiago Creek. Consequently, no sedimentation analysis was required for the project.

Interior Flood Control and Side Drainage

4-50 The flood control project for Santiago Creek will not include any levees or floodwalls that would impede runoff from interior areas from entering the channel. Consequently, the project will induce no adverse interior flood control impacts. However, adequate provisions must be made to ensure that the interior runoff can safely enter the channel at the proper locations without damaging the riprap. Consequently, a side drainage investigation was conducted to locate existing and future locations of side inflow and to estimate design discharges. At the present time local interests have no firm plans for future storm drains in either the reach of the outlet channel or the reach of channel stabilization.

4-51 The local 100-year flood was selected as the design flood for side drainage. Side drain requirements will be satisfied by (1) providing junction structures for existing storm drains; (2) providing inlet structures or confluences for well-defined natural or partly improved tributaries; (3) providing grouted-rock spillways for unconfined shallow side flows in excess of existing drain capacities to enter the channel over the sides. Design discharges for existing drains are generally unavailable. Consequently, drain capacities were conservatively estimated assuming full flow with no pressure head, using the general ground slope along the drain as the slope of the hydraulic grade line. Flows in excess of existing drain capacities will enter the channel through grouted rock spillways located where such flows concentrate under existing conditions. The spillways will be trapezoidal in shape with side slopes of 10 horizontal to 1 vertical. The depths of the spillways were set at 1 foot, and the widths were set to keep the side flow depth to 0.7 feet, assuming critical depth at the crest. A minimum width of 20 feet was used so that maintenance vehicles can easily cross the spillway. Cut-off walls 3 feet deep will be provided at the upper and lower ends to prevent undermining by erosion. The development of side drain discharges is presented in volume 7, section 12. A tabulation of pertinent side drain data is given in table IV-2.

4-52 A 7-foot-high by 7-foot-wide concrete arch storm drain conveys local runoff under Center Drive into the existing gravel pits approximately 850 feet upstream from Prospect Street. This drain conveys local runoff into the pits up to its estimated capacity of 640 ft^3/s. The excess flow of 660 ft^3/s during the local 100-year flood will drain to the southwest away from the location of the drain. Most of the excess runoff will flow directly to the Santa Ana River; the remainder will spread out, commingle with other interior runoff, and enter Santiago Creek at several locations between the pits and the Santa Ana River. Consequently, no provisions for the disposition of excess flow will be required at the drain.

Residual Flooding

4-53 The authorized flood control plan for the Santiago Creek project will provide a 100-year level of protection. For flood control projects in urban areas providing less than standard project flood (SPF) protection, such as the Santiago Creek project, Corps of Engineers guidance calls for providing a description of the consequences of floods exceeding the project capacity. Consequently, the areal extent of flooding for the with-project standard project flood, which has a recurrence interval of approximately 250 years, is displayed in figure 8.

4-54 This overflow map is a modification of the without-project standard project flood overflow map displayed in the Phase I General Design Memorandum. It was possible to utilize the without-project SPF overflow because the limited storage capacity of the pits will result in a insignificant reduction of the SPF peak discharge for with-project conditions. The Phase I GDM overflows were modified by incorporating additional information pertaining to the breakout from the pits at Prospect Street and Bond Avenue. The additional information was taken from the June 1979 flood insurance study for the city of Orange.

Table IV-2. Pertinent Side Drain Data.

RIGHT BANK									
	SUBAREA				SIDE-DRAINAGE REQUIREMENTS				
DRAIN NO.	NAME	SIZE MI^2	DIS-CHARGE PEAK FT^3/SEC	TOTAL Q FT^3/SEC	INDIVID-UAL Q FT^3/SEC	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
1	F3	0.40	293	293	+	Stubout for 18" RCP	289+80	Very localized drainage.	Not required.
2					+	Stubout for 18" RCP	285+50	Very localized drainage.	Not required.
3					20	Stubout for 18" RCP+ 40-foot grouted rock spillway from Sta. 280+80 to 281+20	282+20		13 ft^3/s to spillway.
4					273	Stubout for 66" RCP	265+15	No excess flow.	Not required.
6	H2	0.20	208	78	78	Stubout for 24" RCP+ 40-foot grouted rock spillway from Sta. 58+30 to 58+70	58+30		63 ft^3/s to spillway.
8	H1	0.37	283	283	20	Stubout for 18" RCP	36+60	Excess flows drain W. in River Lane to Drain 11.	13 ft^3/s to U/S Bristol St.
9					24	Stubout for 18" RCP	32+80	DO.	6 ft^3/s to U/S Bristol St.
10						Stubout for 21" RCP	30+90	DO.	
11					180	Stubout for 66" RCP+ 200-foot grouted rock spillway from Sta. 29+60 to 31+60	29+70	Excess flows from Drains 8, 9, 10, and 11 drain to U/S side Bristol Street.	65 ft^3/s to spillway.
13					59	Stubout for 30" RCP+ 40-foot grouted rock spillway from Sta. 14+50 to 14+90	14+30		32 ft^3/s to spillway.

Table IV-2. (Continued)

				LEFT BANK					
	SUBAREA				SIDE-DRAINAGE REQUIREMENTS				
DRAIN NO.	NAME	SIZE MI^2	DIS-CHARGE PEAK FT^3/SEC	TOTAL Q FT^3/SEC	INDIVID-UAL Q FT^3/SEC	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
5	F4	0.76	563	563	563	4'H x 4'W stubout for 3'H x 3.5'W trap. channel	296+30	Formal confluence required if drain is improved by local interests.	473 ft^3/s drains S.W. and enters exist. channel D/S of project limits. No spllwy required.
7	H2	0.20	208	208	130	Stubout for 33" RCP	56+30		114 ft^3/s drains S. away from channel. No spllwy required.
12	--	--	--	--	+	Stubout for 12" CMP	30+80	Very localized drainage.	Ground slopes away from channel. No spillway required.

Hydrologic Facilities

RESERVOIR WATER SURFACE RECORDING SYSTEM

4-55 The device used to record the water surface elevation of the Santiago Creek reservoir will be a servomanometer. This includes a purge bubbler system, a nitrogen storage tank, and a 2-inch rigid water-tight conduit installed just beneath the downstream face of the reservoir that runs from the top down to the reservoir bottom. Two orifices with pull boxes at 0 feet and 20 feet above the bottom will be installed in the 2-inch conduit. In addition, pull boxes will be installed in the conduit every 100 linear feet to provide for installation and repair access to the conduit. Two polyethylene tubes will be inserted within the conduit, one for each orifice. The bottom orifice will be enclosed with a sediment screen/tower, 10 feet high, to protect it from being buried in sediment. A strip-chart water surface recorder will be installed to automatically record water surface measurements from the servomanometer. An 8-foot by 8-foot by 14-foot high concrete house will be constructed on the top of the reservoir to contain the hydrologic instrumentation and to provide AC power. A digital readout display will be attached to the recorder to display the latest recorded measurement.

RESERVOIR STAFF GAUGES

4-56 A series of staff gauge boards will be installed along the upstream face of the reservoir. The boards will be graduated in 0.10 foot increments. Each staff gauge board will be at least 5 feet high and attached to galvanized steel post set in concrete. Each staff board should be installed so as to be readable from the top of the reservoir. The elevation of these staff gauges should be adjustable.

OUTLET GATE RECORDERS

4-57 Each outlet service gate has an automatic recorder to document all gate movements. These recorders will monitor gate settings and make a permanent record of them. They will be connected to the gate control mechanisms and the radio telemetry equipment. The recorders should be automatically activated each time a gate control switch is activated and a recording of the new gate setting with the date and time will be made. This information will be recorded on paper and transmitted to the Los Angeles District Office via the radio telemetry equipment.

PRECIPTATION STATIONS

4-58 Tipping bucket rain gauges will be installed at the control house and at the stream gauging station downstream of the reservoir. The tipping bucket will accumulate .01 inch of rainfall before each tip.

STREAM GAUGING STATION

4-59 An outflow gauging station will be constructed approximately 1,000 feet downstream form the outlet works. An 8-foot by 8-foot by 14-foot high concrete instrument house will be installed to provide shelter and AC power for the hydrologic instrumentation. The stream gauge will be a 35-foot manometer gauge with purge bubbler system and nitrogen storage tank. The measurements from this gauge will be automatically recorded by a strip-cart water level recorder. Staff gauges will also be installed to allow visual measurement of the water surface at the gauge. A digital readout display will be attached to the recorder to display the latest recorded measurement.

RADIO TELEMETRY EQUIPMENT

4-60 A "remote terminal unit" (RTU) entirely compatible with the existing Los Angeles District's telemetry system will be installed at both the Santiago Creek reservoir water surface level control house and the downstream control house. In addition, in order to assist real-time operation of the Santiago Creek reservoir, RTU's will be installed on the water surface recorders of both Santiago Dam and the USGS stream gauge number 11077500, "Santiago Creek at Santa Ana". Each RTU will include a power supply, hydrologic instrument interface, a shaft interface to connect to the water surface recorder, programmable micro-computer control, radio transceiver, and antenna. These RTU's will transmit the gauged information to the District Office via a radio repeater station.

V. GEOLOGY, SOILS, AND MATERIALS

Field investigations were conducted along Santiago Creek for determination of the geology, groundwater, and foundation conditions of the project area. Results of the geotechnical explorations and laboratory testing as well as recommendations for foundation treatment, embankment design, and construction considerations are presented in appendix A entitled Geotechnical Appendix.

VI. STRUCTURAL DESIGN

General

6-01 This section presents the general structural design criteria for the Santiago Creek reservoir outlet structure. The main structural elements include the entrance structure; gate chamber; stilling basin; transition basin; divider walls and concrete culvert section.

References

6-02 Design will be based on accepted engineering practice and will conform to the following Engineering Manuals (EM's), Engineering Technical Letters (ETL's), and Engineering Regulations (ER's):

EM 1110-1-2101	Working Stresses for Structural Design
EM 1110-1-2000	Standard Practice for Concrete
EM 1110-2-2103	Details of Reinforcement - Hydraulic Structures
EM 1110-2-2400	Structural Design of Spillways and Outlet Works
EM 1110-2-2502	Retaining Walls
EM 1110-2-2902	Conduits, Culverts, and Pipes
ER 1110-2-1806	Earthquake Design and Analysis for Corps of Engineers Projects
ETL 1110-2-256	Sliding Stability
ETL 1110-2-312	Strength Design Criteria for Reinforced Hydraulic Structures

Other applicable ETL's, EM's (EM 1110-series), draft EM's, and codes listed therein.

Material Properties Concrete

6-03 Concrete design strengths will be based on 28-day compressive strengths of 3,000 and 4,000 psi. Design will be in accordance with applicable EM's and ETL's.

6-04 The trash structure and all other structures, except concrete box culvert, would be designed using 3,000 psi concrete. The box culvert would be designed using 4,000 psi concrete. ASTM 615 Grades 60 or 40 reinforcing steel would be used where concrete is reinforced. Design yield strengths will be 48,000 psi and 40,000 psi for Grades 60 and 40 steels, respectively. Details of reinforcement would be in accordance with EM 1110-2-2103.

6-05 For the weights and properties of soils refer to Appendix A, titled "Geotechnical."

Table VI-1. Unit Design Stresses.

Concrete	
Cast-in-place structures other than culverts..................	$f'c = 3{,}000\ lb/in^2$
Culverts.......................	$f'c = 4{,}000\ lb/in^2$
Allowable Compressive Strength	
Flexure for retaining walls and floodwalls.................	$fc = 0.35\ f'c = 1{,}055\ lb/in^2$
Flexure for culverts...........	$fc = 0.45\ f'c = 1{,}800\ lb/in^2$
Ratio..........................	$n = Es/Ec$
Modulus of elasticity..........	$Ec = 57{,}000\ (f'c)^{1/2}$
Reinforcing Steel (Grade 40 or 60)	
Allowable tensile strength.....	$fs = 20{,}000\ lb/in^2$
Modulus of Elasticity..........	$Es = 29{,}000{,}000\ lb/in^2$
Design Weights	
Concrete weight................	$Wc = 150\ lb/ft^3$
Water weight...................	$Ww + 62.5\ lb/ft^3$

(Refer to Appendix titled "Geology, Soils, and Materials" for the weights and properties of soils).

Trash Structure

6-06 The reinforced concrete trash structure consists of a front wall, side walls, invert slab and roof slab, which would be used as a working platform. The front wall, normal to the channel center-line, would be located at upstream end of outlet works. The side walls would be rigidly connected to the front wall and flared out, making an angle of 30 degrees with the channel center-line. The length and height for the front and side walls would be approximately 32 feet and 32.5 feet, respectively.

6-07 Sixteen openings, four both vertically and horizontally, would be provided in each wall. Each opening would be 6.5 feet wide and 3.25 feet high. The walls would be rigidly connected to invert slab at bottom and roof slab at top. All trash struts would be designed for minimum water differential head of 5 feet. The roof of the trash structure would be designed as two-way slab, with uniform load of 250 psf or a concentrated load of 3,000 lbs, whichever governs.

Gate Chamber

6-08 The gate structure would be designed in accordance with EM 1110-2-2400. Two radial gates with motorized gate operator located at approximately station 299+90 would be provided. A single transferable bulkhead gate located at approximately station 300+15 would be required.

Stilling Basin

6-09 The stilling basin consist of a parabolic drop portion and a flat portion. Baffle blocks would be located along the flat portion to dissipate energy.

6-10 The wall structure would be designed as a L wall section with width of 64 feet. The L wall section would be designed for two conditions of loading: Condition I (i.e., channel empty), and Condition II (i.e., channel full). For Condition I, earth pressure would be considered to the top of the wall. The lateral earth pressure would be computed for a condition of drained backfill material. The magnitude of combined earth pressure and equipment surcharge loading of a maximum of 200 lb/ft^2 would be applied. Friction with a coefficient of equal to the tangent of the angle of internal friction of the backfill material would be assumed to act on the back of walls. Straight line distribution of soil pressure would be assumed in the design of walls. For Condition II, the hydrostatic pressure of 62.5 lb/ft^3 on the channel side of wall would be balanced by the passive lateral earth pressure acting on the back of the wall, where the backfill is at the top of walls.

Transition Section

6-11 The channel width varies from 64 feet at station 299+13 to 40 feet at station 298+15. The rectangular walls would be designed as L-type walls in accordance with the design presented herein for the stilling basin.

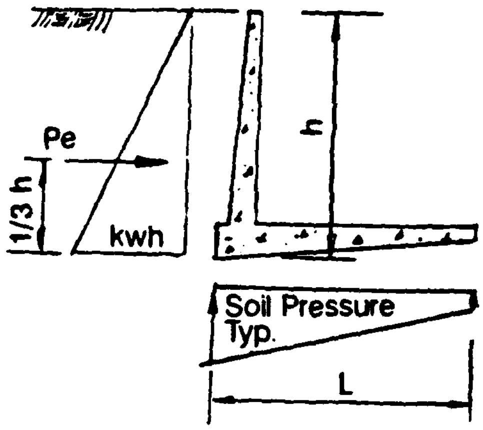
Divider Wall

6-12 Divider walls are provided from station 300+15 to station 298+93 and are located at on third point of the channel width. Divider walls would be designed for maximum wall differential (i.e., channel empty and center channel full or vice versa).

Concrete Box Culverts

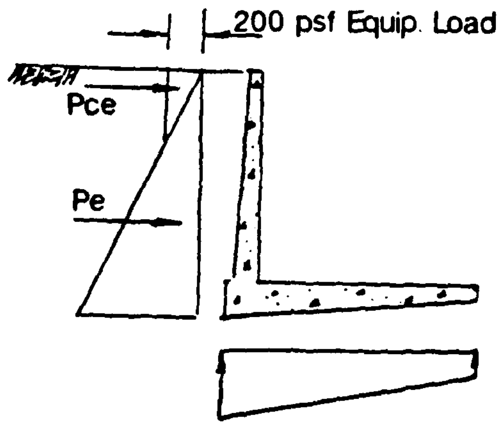
6-13 A double barrel box culvert would be 23 feet wide and 11 feet high for each barrel and 210 feet long. The culvert would be located under Prospect Street. The reinforced concrete box would be designed in accordance with EM 1110-2-2903.

6-14 The loads on the culvert would be vertical and horizontal earth load. Hydrostatic pressures, foundation pressures, and live load, which will be due to highway loading HS 20-44.



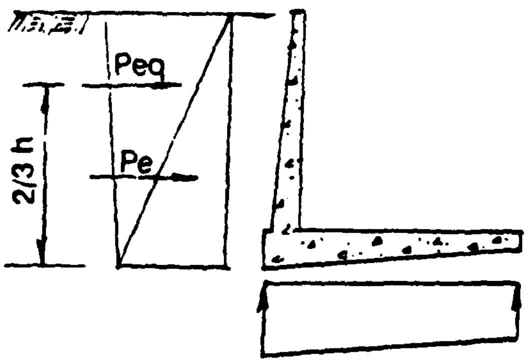
CASE I

Horizontal Earth Pressure



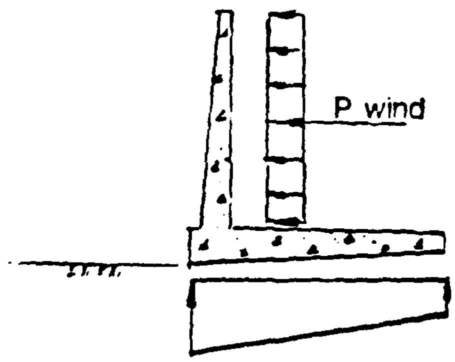
CASE II

Case I with Construction Equipment Load



CASE III

Case I with Seismic Force

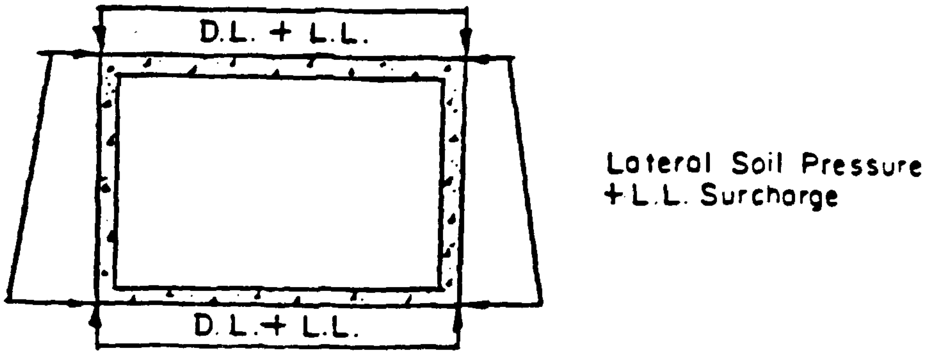


CASE IV

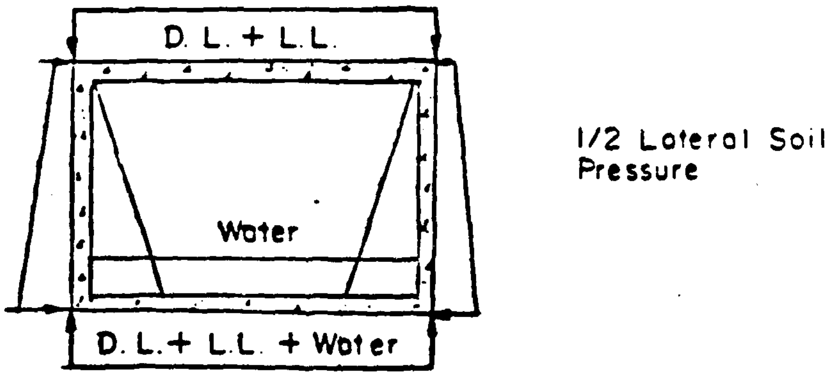
Wind Force with No Backfill under construction

RETAINING WALL LOADING CONDITIONS

Note: Loads are unfactored



CASE I NORMAL LOAD
DESIGN OF CORNER



CASE II NORMAL LOAD WITH WATER
DESIGN OF MIDSPAN

BOX CULVERT LOADING CONDITIONS

Note: Loads are unfactored.

VII. RELOCATION OF STREET AND UTILITY CROSSINGS

General

7-01 The recommended plan would include a gated outlet channel from the Blue Diamond and Bond pits. Construction of this outlet channel would require a detour or temporary crossing of Prospect Street. The proposed channel from Santa Ana Freeway to the Santa Ana River would not require any relocation or modification of highway or street bridges, but certain utilities would require relocation.

Prospect Street

7-02 Due to the short distance from the pits of the outlet channel, construction of the channel would be more economical by open excavation than by tunneling. Since the outlet channel would be located within a horizontal curve of Prospect Street and the street is about 20 feet above the adjacent ground surface, provision of a temporary bypass during the construction of the channel would be difficult and costly. One feasible alternative would be to close the street temporarily during channel construction and divert all vehicular traffic crossing the street to Villa Park Road or Chapman Avenue both of which are approximately one mile away. Construction of the portion of channel under the street and restoration of Prospect Street would take about 4 months.

Utilities

7-03 Construction of the outlet channel from the gravel pits, and the downstream channel from the Santa Ana Freeway to the Santa Ana River, would require relocation or modification of existing utilities. The location, size, type, and owner of existing utilities in the project area are shown in table VII-1.

Table VII-1. List of Existing Utilities.

Channel Station	Existing Utility	Owner	Remarks
298+82	Aerial Telephone		To remain
298+33	3-inch Gas	So. Cal. Gas Co.	To be protected in place
298+24	12-inch Water (abandoned)	City of Orange	To be protected in place
297+08	3-inch Gas	City of Orange	To be relocated
296+00 to 281+00	8-inch Water	City of Orange	To be relocated
266+12	Pipeline	San Diego Pipeline Co.	To be relocated
264+67	24-inch Oil	San Diego Pipeline Co.	To be relocated
262+37	Telephone Cable	Pacific Telephone Co.	To remain
57+36	12-inch		To remain on bridge
57+17	4-inch Gas	So. Cal. Gas Co.	To remain on bridge
56+98	10 3/4-inch Gas	So. Cal. Gas Co.	To remain on bridge
29+62	34-inch Water	Metropolitan Water District	To remain
29+53	18-inch Sewer	City of Santa Ana	To remain
29+24	2-inch Gas	So. Cal. Gas Co.	To remain on bridge
14+30	8-inch Sewer	City of Santa Ana	To remain

VIII. ACCESS ROADS

There will be an access service road provided along the banks of the proposed outlet channel for maintenance and inspection. Vehicular access will be provided from Prospect Avenue which will be constructed of asphaltic concrete. Due to the request of the local sponsor and the restrictive existing rights-of-way there will be no berm access along the proposed riprap channel. The only access for maintenance vehicles to the riprap channel will be along the bottom of the channel and during periods of non-flow in the channel. There will be two access points to the bottom of the riprap channel, one through Hart Park which is approximately 1.1 miles upstream from the riprap channel and the other access point will be from the Santa Ana River at the downstream end of the riprap channel. Fence will be installed at the outlet structure. Existing fence around the gravel pit will be left in place. No other fence will be provided.

IX. ENVIRONMENTAL ANALYSIS

Environmental Impacts

SEDIMENTATION

9-01 The proposed improvements will drastically reduce the amount of sediment that moves down Santiago Creek to the Santa Ana River and the ocean.

WATER RESOURCES

Hydrology and Water Use

9-02 Beneficial impacts occur for water conservation as the gravel pits are modified for flood control.

Water Quality

9-03 Water quality in the area is good. No long-term impact to the water quality is expected as a result of this project. Short-term impact may result from the construction, but will be minimized by operating during the dry season and employing standard construction practices to prevent degradation of water quality.

AIR QUALITY

9-04 Impacts to air quality will be local and short term, due to construction activities, and will primarily be associated with vehicle emissions and dust generation. Increased vehicle emissions will result from heavy equipment use on the construction site, trucks hauling borrow materials to the construction site, if necessary, and from personal vehicles driven by construction workers. Dust generation caused by activities during construction may impact the area of residential development along the creekbed, Chapman General Hospital, and other health units in the area.

LAND USE AND SOCIAL CONCERNS

Important Farmlands

9-05 No farmlands are located within or adjacent to the project area.

Recreation

9-06 No existing recreational facilities will be impacted as a result of this project. No impacts will be associated with the overlook structure or trail.

Growth Inducement

9-07 Growth inducement as a result of the improvement to Santiago Creek is not likely. The areas around much of the proposed improved downstream sections of Santiago Creek are already intensively urbanized. The proposed improved sections around Prospect and Warner Avenues are currently proposed for development.

TRANSPORTATION AND UTILITIES

Facilities

9-08 No streets or railroads will be relocated. The utilities to be relocated are indicated in table VII-1. The Flower Street bridge will not be impacted.

Access

9-09 Access to the project areas will be via local city streets. Although overall traffic patterns and volume should not be significantly impacted, peak traffic hours may be effected. Prospect Street will be closed for the construction of the concrete box channel under Prospect Street for approximately four months.

Transport of Borrow and Disposal Materials

9-10 Borrow materials will be transported on local public roads. Routing plans and time restrictions may be necessary. Any excess excavation shall be disposed of in local disposal pits.

NOISE

9-11 The lower Santiago Creek area is a relatively urban area, with some human-induced noise present due to the presence of residential neighborhoods which run along the length of the downstream portion of the creek. Considerable noise will occur during construction. These short-term impacts are expected particularly to residences which are one to three houses away from the creek. At the upper end of Santiago Creek, noise impacts are not expected to be significant.

BIOLOGICAL RESOURCES

9-12 Material excavated during construction of the Santiago Creek channel will be used to modify and stabilize the slopes of the gravel pit between Prospect Street and Villa Park Road. The remaining volume in the pits is to be used for flood control purposes and, since Orange County Water District now owns the pits, for water conservation. purposes. In the Phase I document, these pits were to be a disposal site for all material excavated from Santiago Channel.

9-13 An overflow structure has been added to the gravel pit since the Phase I SEIS. This structure would occur just upstream from Prospect Street in the existing channel. The structure would occupy about 2.7 acres which would include removal of 1.7 acres of a willow woodland with mulefat and scattered cottonwoods. The remaining area is a disturbed area with roads and some scattered mulefat.

9-14 The widening of the right-of-way at the lower end of Santiago Creek would result in the removal of an increased number of trees. Most of these would be ornamental trees, although there could be some planted sycamores within this area. Nevertheless, because this area is so tightly surrounded by urban development, the loss of biological resource values would not be significant. As mitigation for the loss of 2.2 acres of willow woodland in Santiago Creek, 3.5 acres of willows, cottonwoods, sycamores, and mulefat would be planted and irrigated in areas above the 298-foot elevation in the vicinity of the old Santiago Creek bed, upstream from the overflow structure. The 298-foot elevation is important because the OCWD wants to hold water to this elevation during the dry season.

Endangered and Threatened Species

9-15 Changes in the proposed project for Santiago Creek will not result in any impacts to endangered or threatened species.

CULTURAL RESOURCES

9-16 Two historic bridges have been identified in the reach of the creek to be channelized. Neither of these bridges appears to be eligible for inclusion in the National Register of Historic Places. It does not appear that either of these bridges will be affected by the proposed project. Areas to be impacted by disposal site usage have not been inventoried for the presence of cultural resources as these areas have not yet been identified. Therefore, it is possible that additional impacts, especially to archeological sites, may occur. No paleontological resources are known to occur in this project area, so no mitigation is necessary.

ESTHETICS

9-17 The proposed improvements will generally not significantly impact the existing visually poor gravel pit area. The willow woodland area will suffer a reduction in visual quality due to construction of the overflow structure. Replacing of the willow woodland will alleviate visual impacts. Downstream view of the creek from adjacent houses and street overpasses will suffer due to removal of all vegetation in the channel. Planting will be accomplished along the fenceline to reduce the esthetic impact. The basic concept is to provide a landscape plan that would minimize the detrimental visual impact of the flood control project. Emphasis will be to incorporate a landscape compatible with the surroundings, such as indigenous native plant material or ornamental plantings in an attempt to maintain the identity and character of that particular reach. For areas of limited right-of-way (less than 5 feet in width) hydroseed and stones will be used for erosion control.

PUBLIC SAFETY

9-17 No access road will be maintained between Santa Ana River and the Santa Ana Freeway.

X. DIVERSION AND CONTROL OF WATER DURING CONSTRUCTION

10-01 According to available climatological information, southern California has a warm and dry period between April 15 and October 15, and a cool and rainy period from October 15 to April 15. The existing Santiago Dam intercepts most of the runoff from a large percentage of the project drainage area, and Villa Park Dam has the capacity to control floods up to 70-year frequency to an outflow of 3,500 ft^3/s. In addition, the existing Blue Diamond and Bond pits would retain some of the releases from Villa Park Dam. Flooding of the construction area could be the result of either an unseasonal thunderstorm event or unusually heavy rainfall over the uncontrolled drainage area downstream from Villa Park Dam. Construction of Santiago Creek Channel would be scheduled during the dry period of the year (April 15 to October 15) to minimize the need for extensive water diversion facilities.

10-02 Both the outlet channel and downstream channels are comparatively short and construction should be completed within the dry period of the year. Local water flowing in the streambed can be controlled within the construction area by cofferdams, dikes, and pumps.

XI. REAL ESTATE REQUIREMENTS

General

11-01 Santiago Creek is the largest tributary to the Santa Ana River downstream from Prado Dam originating on the western slopes of the Santa Ana Mountains. Most of the areas to be taken in flowage easements are owned by the Orange County Water District and consist primarily of depleted or nearly depleted gravel pits. The area is zoned for sand and gravel mining. These pits were acquired in 1984 by the Water District for both water conservation and flood control use. An estimated 281.5 acres are needed for the project with 272.5 acres owned by Orange County Water District. The balance is made up of small private ownerships. There is one dwelling within the area to be taken. The Standard Corps of Engineers Flowage Easement (Occasional Flooding) will be amended to provide for the Orange County Water District's residual use of the area for water conservation purposes. The flowage easement language with the amended portion is included hereafter.

Estimated Cost

11-02 The estimated costs of lands and easements are provided below.

Land	$3,723,000
Improvements	150,000
Damages	186,000
Contingencies (20%)	812,000
Relocations	15,000
Administrative Costs	198,000
Total estimated costs	$5,084,000

STANDARD CORPS OF ENGINEERS FLOWAGE EASEMENT

WITH MODIFICATION (UNDERLINED)

NECESSARY TO ACCOMMODATE

RESIDUAL USE BY

ORANGE COUNTY WATER CONSERVATION DISTRICT

11-03 The perpetual right, power, privilege and easement occasionally to overflow, flood and submerge (the land described in Schedule A) in connection with the operation and maintenance of the Santa Ana River Mainstem Flood Control Project as authorized by the Act of Congress approved____________________, together with all right, title and interest in and to the structures and improvements now situate on the land, except fencing, provided that no structures for human habitation shall be constructed or maintained on the land nor shall any other structures be constructed or maintained except as may be approved in writing by the representative of the United States in charge of the project. No excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill.

The above estate is taken subject to existing easements for public roads and highways, public utilities, railroads, and pipelines; reserving to the grantor, its heirs and assigns, all such rights and privileges as may be used and enjoyed, <u>including the residual use of the area herein described for the purpose of water conservation to elevation 274 feet Mean Sea Level (M.S.L.). Said right of residual use shall include the right to construct and operate an outlet gate for the purpose of maintaining and controlling the water conservation pool to a maximum elevation of 274 feet M.S.L.</u> The rights reserved to the grantor shall not interfere with the use of the project for the purpose authorized by Congress or abridge the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

XII. COST ESTIMATES

First Cost

12-01 The first cost for Santiago Creek based on October 1987 price level, including construction, engineering and design, and rights-of-way is presently estimated at $15,139,000. The unit prices were based on bid prices for similar flood control projects in southern California. Adjustment was made to these unit prices to reflect the specific project conditions such as accessibility, size of the project, and unusual types of construction. In compliance with EM 1110-2-1301, a 15 percent contingency was added to the estimated construction cost. For engineering and design, and supervision and administration, 10 and 6 percent of the construction cost were chosen, respectively, based on the rates within the Los Angeles District. The costs for lands and damages were determined by gross appraisals. The detailed first cost estimate is presented in table XII-2.

Comparison of Estimates

12-02 The Phase I GDM cost estimate for Santiago Creek using October 1987 price level is estimated at $14,720,000. The first cost is estimated to be $15,143,000 using October 1987 price levels. The comparison of each cost is presented in table XII-3. The difference of $423,000 between the Phase I GDM (Oct 1987 price level) cost estimate and first cost estimate are explained as follows:

a. An increase of $13,000 due to the increase of utilities required for the project.

b. An increase of $186,000 due to an increase of cost for fill material and to excavate.

c. An increase of $35,000 due to diversion and control of water.

d. An increase of $244,000 for clearing and removing of obstructions which was not included in the Phase I GDM.

e. A decrease of $1,519,000 due to the elimination of the inlet structure.

f. An increase of $1,543,000 due to the outlet structure change in design to include an overflow structure and an increase to the upstream trapezoidal channel of 715 L.F.

g. An increase of $29,000 for an additional access roads which was not included in the Phase I GDM.

h. An increase of $194,000 due to the increase of 420 L.F. of the downstream trapezoidal channel.

i. A decrease of $409,000 due to less esthetic treatment required.

j. An increase of $55,000 due to permanent operating equipment which was not included in the Phase I GDM.

k. An increase of $74,000 due to mitigation requirements which was not included in the Phase I GDM.

l. An increase of $114,000 due to engineering and design necessary.

m. An increase of $31,000 due to supervision and administration necessary.

n. An increase of $30,000 due to an operation and maintenance manual not included in the Phase I GDM.

o. A decrease of $116,000 due to a decrease in the cost of real estate.

p. An increase of $25,000 due to a detour at Prospect Street which was not included in the Phase I GDM.

q. A decrease of $440,000 for relocation costs due to the elimination of a bridge at the inlet structure.

r. An increase of $334,000 due to Preconstruction Engineering and Design requirements which were not included in the Phase I GDM.

Table XII-1. Summary of First Cost.
(October 1987 Price Level)

Acct. No.	Description	Amount
02	Relocations	$23,000
03	Reservoirs	1,672,000
09	Channel	
	Diversion and Control of Water	73,000
	Clear and Remove Obstructions	244,000
	Outlet Structure & Channel (sta. 300+12 to sta. 252+00)	4,379,000
	Access Roads	
	Asphaltic Concrete	61,000
	Lower Channel	
	Station 74+35 to Station 10+15	1,583,000
	**Esthetic Treatment	171,000
	Mitigation (Planting)	74,000
20	Permanent Operations Equipment	55,000
30	Engineering and Design	834,000
31	Supervision and Administration	501,000
51.22	Operation and Maintenance Manual	30,000
	Total, Construction	9,700,000
	***Total, Lands, Damages and Relocations	5,109,000
	Preconstruction Engineering & Design	334,000
	Total, Flood Control First Cost	15,143,000
14	*Total, Recreation Development	194,000
	GRAND TOTAL PROJECT COST	$15,337,000

*See appendix B for cost breakdown.
**See table XIV-2 for cost breakdown.
***See para. 11-02 for cost breakdown.

Table XII-2. Detailed Estimate of First Cost.
(October 1987 Price Level)

Acct. No.	Description	Unit	Quantity	Unit Price	Sub-total	Total
02	Relocations:					
	Utilities	Job	1	L.S.	$20,000	
	Subtotal Utilities				20,000	
	Contingencies (15%)				3,000	
	Total Utilities					$23,000
03	Reservoirs:					
	Excavation	C.Y.	199,600	2.40	$479,000	
	Fill	C.Y.	325,000	3.00	975,000	
	Subtotal Reservoirs				$1,454,000	
	Contingencies (15%)				218,000	
	Total Reservoirs					$1,672,000
09	Channel Costs, Station 300+12 to Station 252+00:					
	Diversion and Control of Water	Job	1	L.S.	32,000	
	Clear and Remove Obstructions	Job	1	L.S.	100,000	
	Outlet Structure:					
	Excavation	C.Y.	29,000	2.40	70,000	
	Fill	C.Y.	11,600	3.00	35,000	
	Concrete:					
	Invert	C.Y.	1,200	90.00	108,000	
	Walls	C.Y.	1,200	153.00	184,000	
	Soffit	C.Y.	350	156.00	55,000	
	Baffle Blocks	Ea.	18	206.00	4,000	
	Flood Walls	C.Y.	345	153.00	53,000	
	Reinforced Steel	L.B.	309,500	.42	130,000	
	Trash Structure	Job	1	L.S.	49,000	
	Radial Gates	Ea.	2	192,400	385,000	
	Bulkhead Gate	Ea.	1	35,000	35,000	
	Anti-Vortex Plate	Job	1	L.S.	5,000	
	Emergency Generator & Misc.	Job	1	L.S.	182,000	
	Overflow Structure					
	Excavation	C.Y.	44,221	2.40	106,000	
	Grouted Stone	C.Y.	2,780	70.00	195,000	

Table XII-2. (Continued)

Acct. No.	Description	Unit	Quantity	Unit Price	Sub-total	Total
	Outlet Channel:					
	Excavation	C.Y.	61,000	2.40	146,000	
	Fill	C.Y.	13,000	3.00	39,000	
	Concrete					
	Invert	C.Y.	2,700	90.00	243,000	
	Walls	C.Y.	700	153.00	107,000	
	Soffit	C.Y.	1,200	156.00	187,000	
	Reinforced Steel	L.B.	460,000	0.42	193,000	
	Excavation	C.Y.	259,600	2.40	623,000	
	Fill	C.Y.	15,900	3.00	48,000	
	Riprap	Ton	21,100	21.00	443,000	
	Filter Material	C.Y.	7,700	23.00	177,000	
	Grouted Stone	Job	1	L.S.	10,000	
	Access Roads:					
	Asphaltic Concrete	Ton	1,100	48.00	53,000	
	Lower Channel Station 74+35 to Station 10+15:					
	Diversion & Control of Water	Job	1	L.S.	31,000	
	Clear & Remove Obstructions	Job	1	L.S.	112,000	
	Excavation	C.Y.	41,400	3.31	137,000	
	Fill	C.Y.	13,277	2.50	33,000	
	Riprap	Ton	47,397	19.96	946,000	
	Filter Material	C.Y.	11,537	23.00	265,000	
	**Esthetic Treatment	Job	1	L.S.	149,000	
	Mitigation (Planting)	Job	1	L.S.	65,000	
	Subtotal Channel				5,735,000	
	Contingencies				850,000	
	Total Channel					6,585,000
20	Permanent Operations	Job	1	L.S.	48,000	
	Subtotal Permanent Operations				48,000	
	Contingencies (15%)				7,000	
	Total Permanent Operations					55,000

Table XII-2. (Continued)

Acct. No.	Description	Unit	Quantity	Unit Price	Sub-total	Total
	Subtotal Relocations, Reservoirs, Channels & Permanent Operations Equipment				7,257,000	
	Contingencies				1,078,000	
	Total Relocations, Reservoirs, Channels, & Permanent Operations Equipment					8,335,000
30	Engineering and Design (10%):				834,000	
31	Supervision and Administration (6%):				501,000	
51.22	Operation and Maintenance Manual				30,000	
	Total Construction					9,700,000
	Lands and Damages					
	***Lands	Job	1	L.S.	5,084,000	
	Relocations					
	Prospect Detour	Job	1	L.S.	25,000	
	Total, Lands Damages and Relocations:					5,109,000
	Preconstruction Engineering & Design				334,000	
	Total Flood Control First Cost					15,143,000
*14	Total Recreation Development (100% cost)				194,000	
	Grand Total Project Cost					$15,337,000

*See appendix B for cost breakdown.
**See table XIV-2 for cost breakdown.
***See para. 11-02 for cost breakdown.

Table XII-3. Comparison of First Cost.

Acct. No.	Description	Phase I GDM (Est) (Oct. 1979 Price Level)	Phase I GDM (Est) (Oct. 1987 Price Level)	Present Estimate (Oct. 1987 Price Level)
02	Relocations	$8,000	$10,000	$23,000
03	Reservoirs	999,000	1,486,000	1,672,000
09	Channel			
	Diversion & Control of Water	25,000	38,000	73,000
	Clear & Remove Obstructions	( )	( )	244,000
	Inlet Structure	1,021,000	1,519,000	( )
	Outlet Structure	1,907,000	2,836,000	4,379,000
	Access Road			
	Asphaltic Concrete	21,000	32,000	61,000
	Lower Channel			
	Station 74+35 to Station 10+15	934,000	1,389,000	1,583,000
	**Esthetic Treatment	390,000	580,000	171,000
	Mitigation (Planting)	( )	( )	74,000
20	Permanent Operations Equipment	( )	( )	55,000
	Subtotal Construction	5,305,000	7,890,000	8,335,000
30	Engineering and Design	530,000	720,000	834,000
31	Supervision and Administration	371,000	470,000	501,000
51.22	Operation nd Maintenance Manual	( )	( )	30,000
	Total Construction	6,206,000	9,080,000	9,700,000
	Lands and Damages			
	***Lands	3,500,000	5,200,000	5,084,000
	Relocations			
	Prospect Detour	( )	( )	25,000
	Bridge	297,000	440,000	( )
	Total Lands, Damages and Relocations	3,797,000	5,640,000	5,109,000

Table XII-3. (Continued)

No.	Description	Phase I GDM (Est) (Oct. 1979 Price Level)	Phase I GDM (Est) (Oct. 1987 Price Level)	Present Estimate (Oct. 1987 Price Level)
	Preconstruction Engineering & Design	( )	( )	334,000
	Total Flood Control First Cost	$10,003,000	$14,720,000	$15,143,000
	*Total Recreation Development (100% cost)	410,000	600,000	194,000
	GRAND TOTAL PROJECT COST	$10,413,000	$15,320,000	$15,337,000

*See appendix B for cost breakdown.
**See table XIV-2 for cost breakdown.
***See para. 11-02 for cost breakdown.
Note: ( ) indicates there was no cost included for that item.

XIII. DESIGN AND CONSTRUCTION SCHEDULE

Preparation of Plans and Specifications

13-01 Preparation of contract plans and specifications for the construction of the proposed flood control project will be initiated after the Phase II GDM for the Santa Ana River Project is approved. Contract plans and specifications would take approximately 15 months to complete.

Construction Schedule

13-02 Construction would be scheduled to start in the spring of the year. Construction of the improvements will take approximately 12 months. Table XVII-1 shows a generalized construction schedule. The construction schedule shown may be modified as required based on total project requirements. The overall project construction schedule is provided in the Main Report.

Total Federal Funds Required By Fiscal Years

13-03 Funding required for the project is shown in table XVII-1. Total funds including Federal and non-Federal share which will be required for the preparation of contract plans and specifications and the construction of the project is shown in the Main Report which includes a schedule. The breakdown by fiscal year of the Federal and non-Federal plan is presented in the Main Report.

Survey and Mapping Requirements

13-04 The topographic maps used for this portion of the design were developed in February 1980. The maps will be approximately 10 years old at the time of construction. Prior to any construction the maps of the gravel pits at a minimum need to be field verified and updated to reflect any changes. Topographic mapping of the outlet structure area and the downstream channel including accurate fence locations need to be obtained at a scale of 1" = 20'.

LINE NO	UNIFORM COST CLASSIFICATION	FEATURE ITEMS	PROJECT COST ESTIMATE	TOTAL AS OF	19
1	02	RELOCATIONS	23		
2					
3	03	RESERVOIRS	1,672		
4					
5	09	OUTLET STRUCTURE AND CONCRETE			
6		CHANNEL STA.300 + 12 TO STA.252+00	4,766		
7					
8	09	RIPRAP CHANNEL STA.74 + 35 TO STA.10+15	1,819		
9					
10	20	PERMANENT OPERATIONS EQUIPMENT	55		
11					
12	30	ENGINEERING AND DESIGN	834		
13					
14	31	SUPERVISION AND ADMINISTRATION	501		
15					
16	51.22	OPERATION AND MAINTENANCE MANUAL	30		
17					
18		LANDS AND DAMAGES	5,084		
19		RELOCATIONS	25		
20					
21		PRECONSTRUCTION ENGINEERING AND DESIGN	334		
22					
23		TOTAL FLOOD CONTROL FIRST COST	15,143		
24					
25	14	TOTAL RECREATION DEVELOPMENT(100%COST)	194		
26					
27		GRAND TOTAL PROJECT COST	15,337		

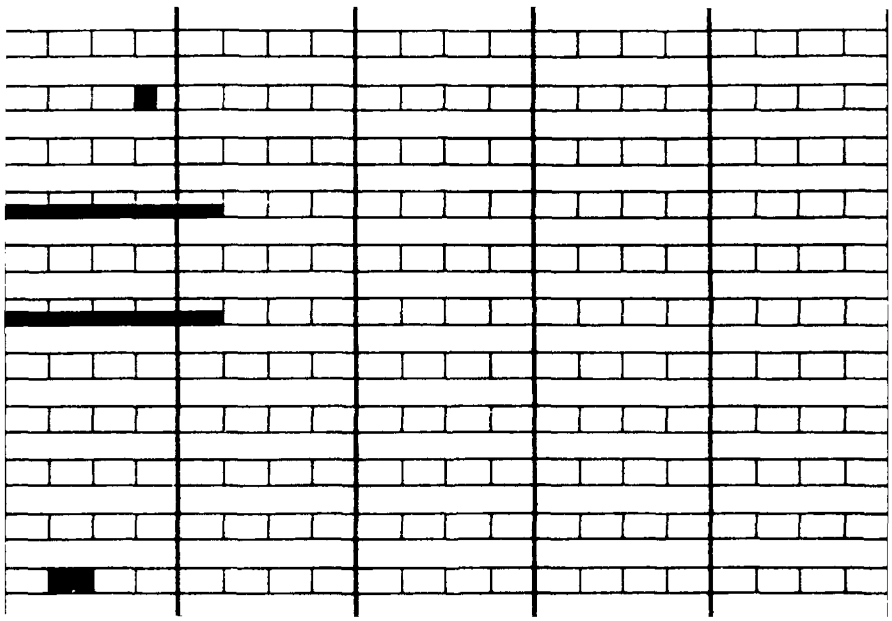
FUNDS IN THOUSANDS OF DOLLARS

DESIGN

NO ACTIVITY

CONSTRUCTION

SPL FORM 571
1 NOV 72



XIV. ESTHETIC TREATMENT

Introduction

14-01 The basic concept for esthetic treatment of the Santiago Creek is to provide a landscape plan that would minimize the detrimental visual effects of the flood control project (concrete and riprap channel and existing chain-link fence along the channel) on the surrounding environment. A combination of trees (overstory), shrubs (understory), would be carefully selected to provide for the functional application of screening, erosion control, scale and visual enhancement by breaking up the harsh linear element that the concrete channel produces.

General

14-02 Santiago Creek has been divided into four sections which are called reaches. These "reaches" are defined as follows:

Reach 1 - From the Santa Ana River upstream to the Santa Ana Freeway. This reach will incorporate both a trapezoidal channel and a rectangular channel. The rectangular section will be utilized in areas of limited right-of-way. These narrow areas extend from 600 feet upstream of Bristol Street to Flower Street and also 600 feet upstream from Flower Street for an additional 200 feet.

Reach 2 - From Santa Ana Freeway upstream to Walnut Avenue. There will be no esthetic treatment done over this reach.

Reach 3 - From Walnut Avenue to Prospect Street. The channel will be trapezoidal and the reach also includes an outlet structure which will control the water elevation at the proposed reservoirs.

Reach 4 - From Prospect Street to Villa Park Road. This reach includes the abandoned Bond and Blue Diamond gravel pits. These pits will be used as reservoirs, for a water conservation program proposed by the Orange County Water District and for the flood control project proposed by the Corps of Engineers. This reach contains a substantial stand of native and riparian vegetation. There will be no landscape development within the gravel pits. However, there will be landscape development within the right-of-way of the outlet/overflow structure area.

14-03 Due to the limited right-of-way areas available in certain reaches of the channel, trees or shrubs would not be recommended within a space less than 5 feet in width. These areas will be hydroseeded to provide a ground cover for erosion control.

14-04 Gradually, emphasis would be placed on incorporating a landscape compatible with the immediate surroundings, such as indigenous native plant material or ornamental plantings which match the adjacent natural or urban environment. This would maintain the identity and character of that particular reach. A drip irrigation system would be provided to establish the plant material. After plant establishment, which is estimated to be from 3 to 5 years, the system could be shut-down, abandoned or removed. The native plant species which will be considered is listed in table XIV-1. The detailed present cost estimated for the landscaping and irrigation is presented in table XIV-2. The esthetic treatment plan for station 300+12 to station 252+00 is shown on plate 22 and for station 74+35 to station 10+15 is shown on plate 23.

14-05 The following native type plant species would be considered for planting within the rights-of-way:

TREES

Populus fremontii	Fremont Cottonwood
Platanus racemosa	California Sycamore
Alnus rhombifolia	White Alder
Populus trichocarpa	Black Cottonwood
Salix gooddingii	Black Willow
Salix hindsiana	Sandbar Willow
Salix laevigata	Red Willow
Salix lasiolepis	Arroyo Willow
Sambucus mexicana	Mexican Elderberry

SHRUBS:

Cercocarpus betuloides	Mountain Mahogany
Eriogonum fasciculatum	Common Buckwheat
Lotus scoparius	Deerweed
Artemesia californica	California Sagebrush
Encelia californica	Desert Encelia
Salvia apiana	White Sage
Salvia mellifera	Black Sage
Artemesia dracunculus	Dragon Sagewort

14-06 Ornamental species would also be considered for planting within the rights-of-way to match adjacent development. Inventory of existing species would be compiled prior to development of plans and specifications.

Table XIV-1. Detailed Cost Estimate for Landscaping and Irrigation. Santiago Creek (October 1987 Price Level)

Item No.	Description	Unit	Qty.	Unit Cost	Sub-Total	Total
1	15 Gal. Trees (single-stake)	EA	412	$80.00	$32,960	
2	5 Gal. Shrubs	EA	1,114	32.00	35,650	
3	Drip-irrigation system					
	2" PVC Mainline	LF	11,635	1.90	22,110	
	1/4" Drip line tubing	LF	15,260	.15	2,290	
	2.0 GPH Emitters Two per tree	EA	830	1.00	830	
	.5 GPH Emitters Two per shrub	EA	2,230	.90	2,010	
	Misc. components for drip-irrig.	L.S.	1	12,000.00	12,000	
4	Seeding w/soil prep. and amend.	S.F.	125,750	.23	28,920	
5	90 Days Maintenance and Plant Establish Period	L.S.	1	12,000.00	12,000	
	Subtotal				148,770	
	Contingencies (15%)				22,315	
	Subtotal Construction				171,085	
	Engineering and Design (10%)				17,108	
	Supervision and Administration (6%)				10,265	
	TOTAL COST					$198,458

XV. RESERVOIR REGULATION

15-01 Santiago Creek Reservoir will have a flood control storage allocation of 4,620 acre-feet between elevations 274 feet and 298 feet. A portion of this storage may be used for water conservation depending on the season of the year. That is, the amount of storage above elevation 274 reserved for flood control only, may vary with the time of the year. Storage below elevation 274 feet will be used for water conservation. Santiago Creek Reservoir flood control storage will be used to control discharge in Santiago Creek from the pits to the confluence with the Santa Ana River so that outflow from the pits when combined with runoff from the drainage area downstream will not exceed the design discharge of Santiago Creek, which is 5,000 ft^3/s at the mouth. Any water control plan developed for Santiago Creek Reservoir should not violate this criteria or be interpreted in a way that violates it. In addition, Santiago Creek Reservoir can be used, if necessary, to help control flooding on the Santa Ana River downstream of the confluence with Santiago Creek by reducing outflow from the reservoir if local conditions warrant it. The stream gauges downstream of the reservoir and at the mouth of Santiago Creek should be used to guide releases from the reservoir. Additional information on Santiago Creek Reservoir regulation can be found in the Hydrology Appendix of this GDM.

15-02 The design water control plan for flood control for Santiago Creek Reservoir during December through March is to maintain outflow from the flood control storage equal to inflow up to a maximum of 3,500 ft^3/s. For the general storm design flood, the 100-year contemporaneous runoff from the area downstream of the reservoir, added to 3,500 ft^3/s outflow from the reservoir, results in a peak discharge of 5,000 ft^3/s at the mouth of Santiago Creek at the Santa Ana River.

15-03 The design water control plan for flood control for Santiago Creek Reservoir during April through November is to maintain outflow from the flood control storage equal to outflow from Villa Park Dam up to a maximum of 3,500 ft^3/s. For the 100-year flood generated by a local storm, the runoff from the area downstream of Santiago Creek Reservoir could result in a peak discharge of 5,000 ft^3/s at the mouth of Santiago Creek without any outflow from Santiago Creek Reservoir. Therefore, in order for this water control plan to be able to control the 100-year flood generated by a local storm, there must be adequate flood control storage space available to capture the runoff from the area between Villa Park Dam and Santiago Creek Reservoir, with no outflow from Villa Park Dam.

15-04 The water surface elevations at Santiago Dam and Villa Park Dam upstream of the proposed Santiago Creek Reservoir, and the time of the year during which storage is taking place, will be used to determine the bottom elevation of flood control storage. Table XV-1 is the design used to determine the bottom elevation of flood control storage for Santiago Creek reservoir. It also shows the corresponding bottom elevation of flood control storage for Villa park Dam as specified by OCEMA's "Villa Park Dam Operation Manual", dated 3 July 1985. The lowest bottom elevation of flood control storage for Santiago Creek Reservoir is 274 feet NGVD. During rising water surface elevations of the reservoir, when the bottom elevation of flood control storage is reached, the outlet works are operated so that outflow is as specified in paragraph 15-02 or 15-03 above. During falling water surface elevations, after the peak water surface elevation has occurred, the maximum outflow is maintained until the bottom elevation of the flood control storage is reached.

15-05 The proposed Santiago Creek Reservoir outlet works will be operated by the Orange County Environmental Management Agency (OCEMA). OCEMA will be responsible for operating the outlet gates whenever water control operations are necessary. These gate operations will be in accordance with instructions to be provided by the Los Angeles District. They will be issued in a manual entitled "Standing Instructions to the Project Operator for Flood Control". These instructions will specify the water control plan to follow when water is stored in the flood control storage space. They will be based on the criteria included in this General Design Memorandum and may vary somewhat from the "design" water control plan described above, but not from the general criteria described above in paragraph 15-01. These instructions will be issued to the OCEMA upon completion of the project construction.

Table XV-1. Bottom Elevation of Flood Control Storage
Villa Park and Santiago Creek Reservoirs

	December through February		During March	
Santiago Dam at or Below Water Surface Elevation	Villa Park Dam At or Below Water Surface Elevation	Santiago Creek At or Below Water Surface Elevation	Villa Park Dam At or Below Water Surface Elevation	Santiago Creek At or Below Water Surface Elevation
790	510	274	510	280
789	510	278	510	280
788	510	280	510	280
787	510	280	510	281
786	510	280	510	282
784	510	280	510	284
782	510	280	510	286
780	510	280	510	288
778	510	280	521	290
776	510	280	529	293

During the period of April through November the bottom elevation of the flood control storage of the reservoir will be elevation 293 feet regardless of the storage space available in Santiago Dam and Villa Park Dam.

See paragraphs 15-01 through 15-03 to determine the outflow from Santiago Creek Reservoir. Outflow from Villa Park Dam will be as specified in the OCEMA "Villa Park Dam Operational Manual."

XVI. OPERATION AND MAINTENANCE

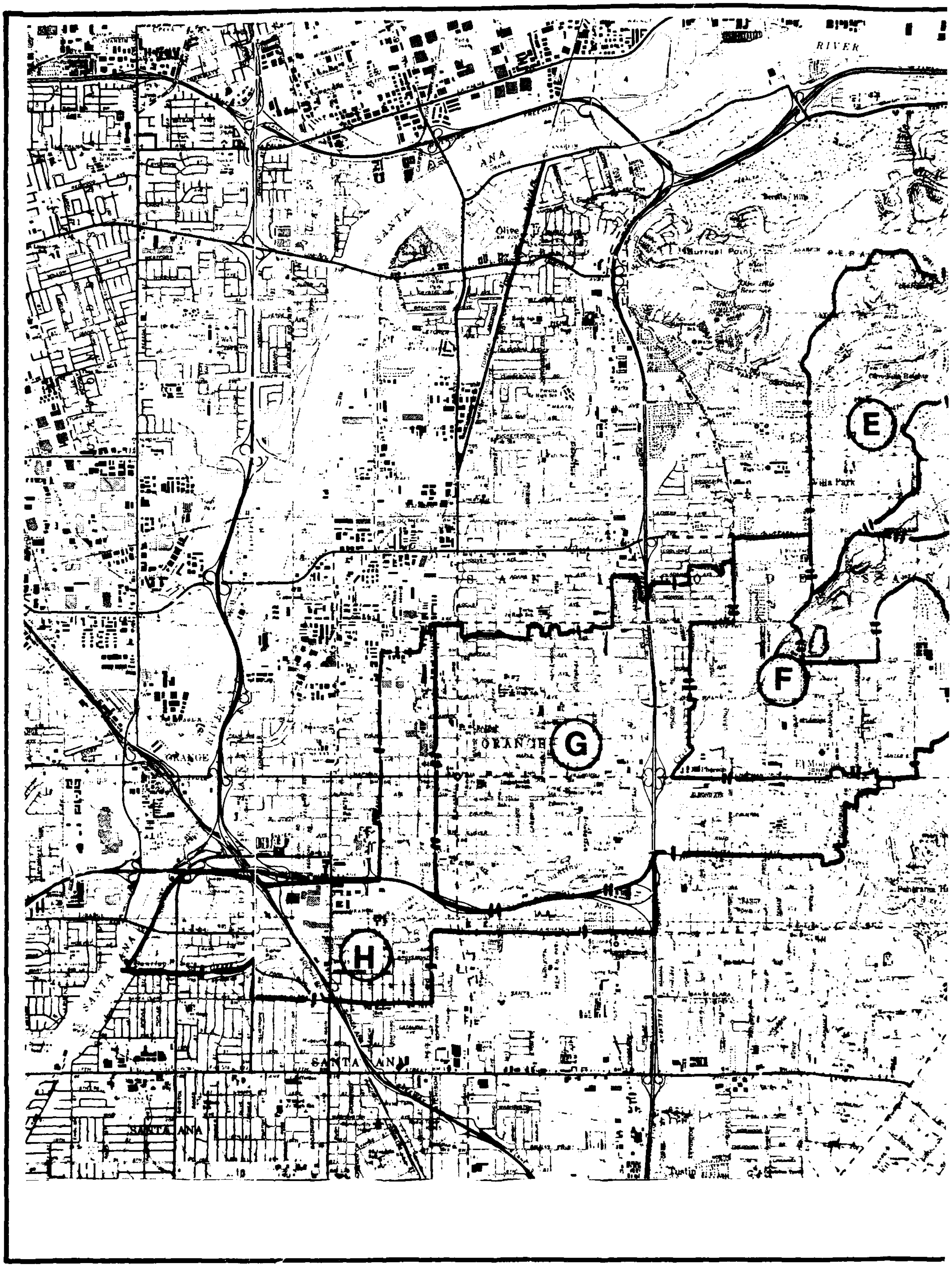
Introduction

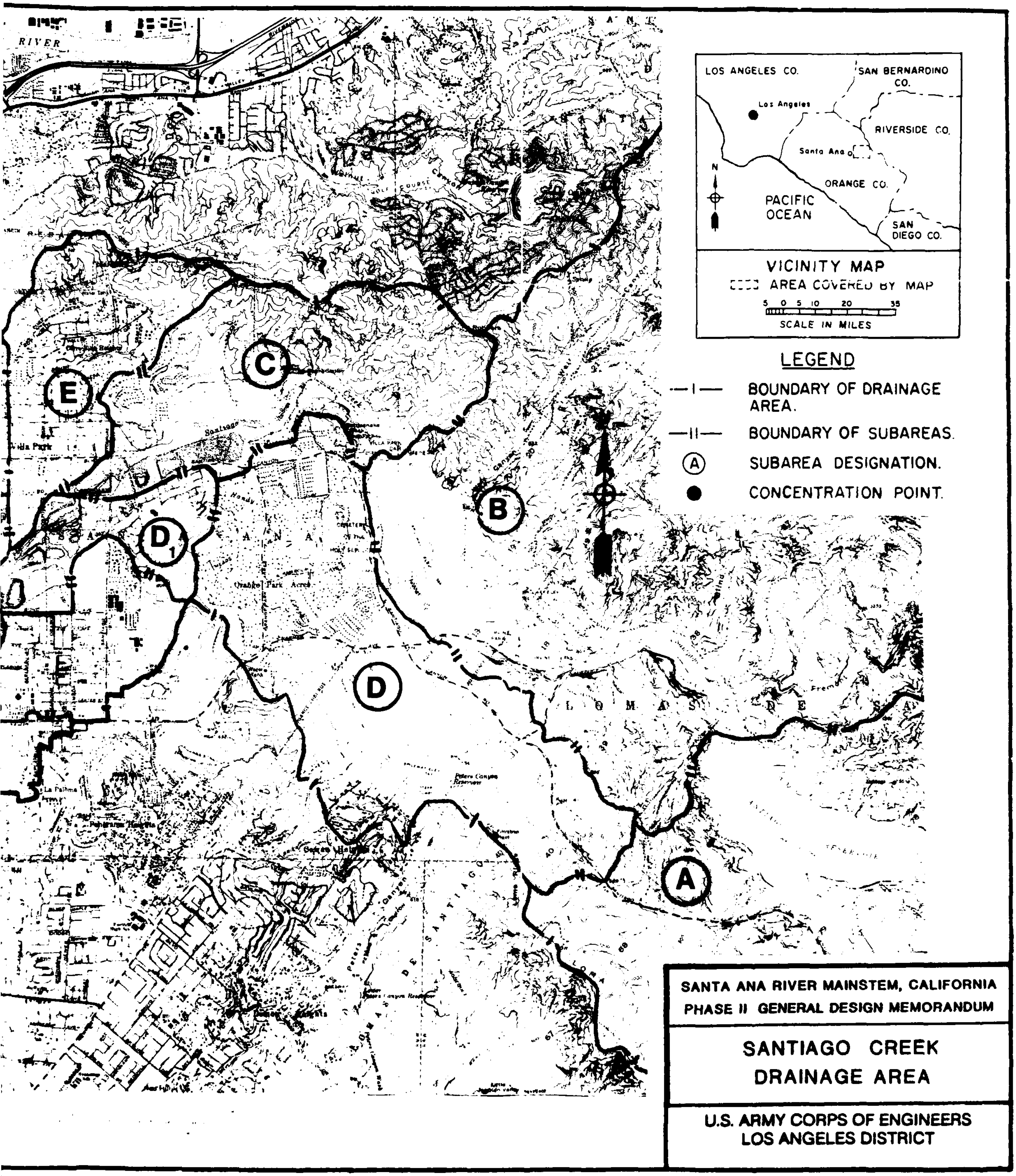
16-01 An operation and maintenance (O&M) manual would be prepared after construction of the flood control improvements in accordance with ER 1130-2-304 "Project Operations" and applicable provisions of ER 1150-2-301 "Local Cooperation." The estimated cost of the O&M manual is $30,000. The local sponsor would be responsible for the operation and maintenenace of the flood control improvements. In general the major items of operation and maintenance and their estimated annual costs would be as follows:

Table XVI-1. Annual Operation and Maintenace Cost

Item	Annual Cost
Operation	
Administration	$5,000
Inspection and Evaluation	$3,000
Gate Operator (as required)	$20,000
Maintenance	
Routine (fence repair, riprap, weeds, equipment, sealing, debris, cleanup, etc.)	$15,000
Gate Painting and Repair (5 years)	$10,000
Miscellaneous	$5,000
Major Replacement	
Access Road (30 years)	$3,000
Gate Replacement (50 years)	$10,000
Subtotal	$71,000
Contingency (15%)	$11,000
Total	$82,000

16-02 The operation of the outlet gates is predicated on the operational release schedule for Villa Park Dam. The project operation and maintenance manual will contain the release schedule for Villa Park Dam.


RIVER
SANTA ANA
Olive
Villa Park
E
F
G
H
ORANGE
SANTA ANA
Tustin

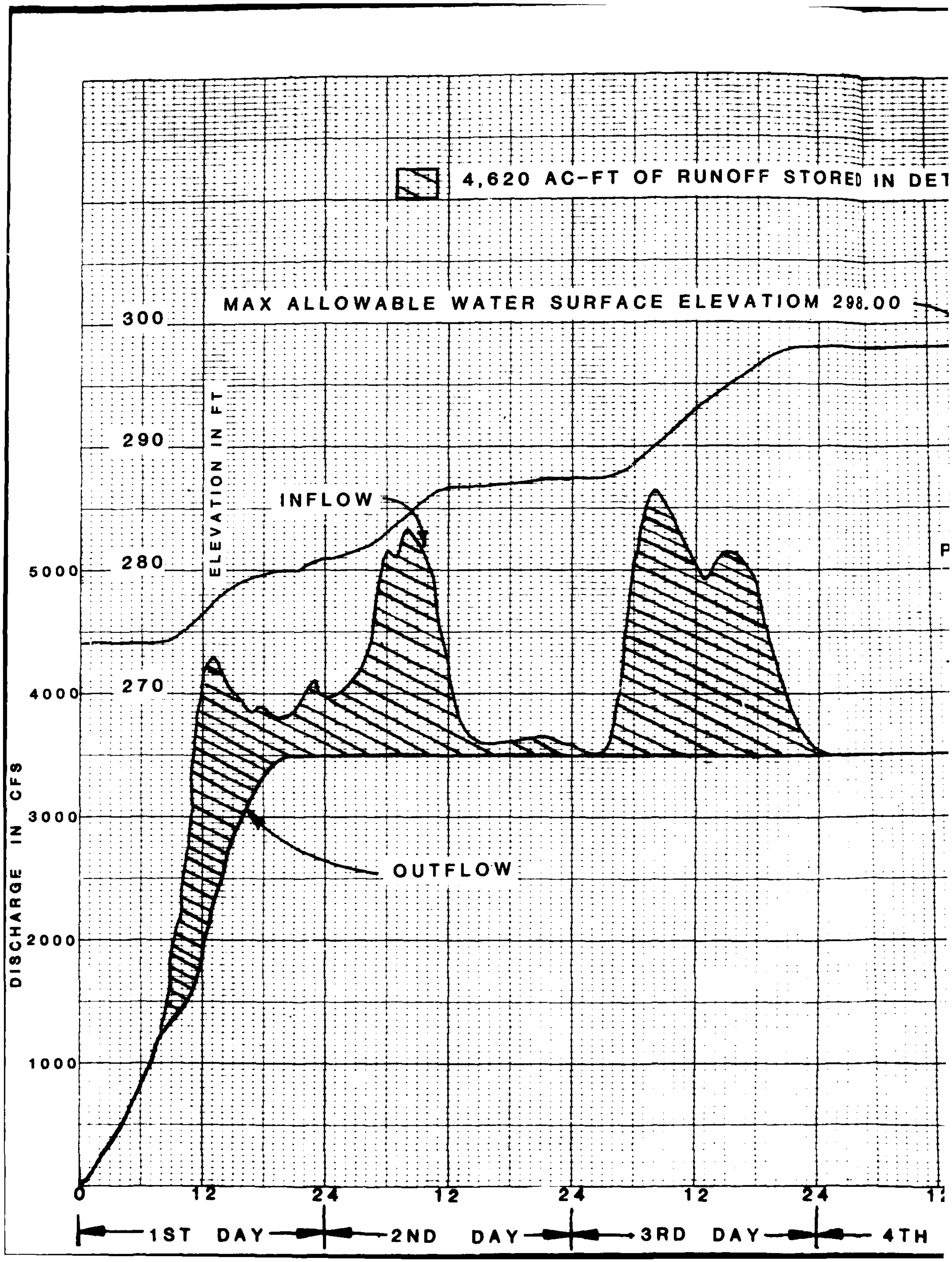


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

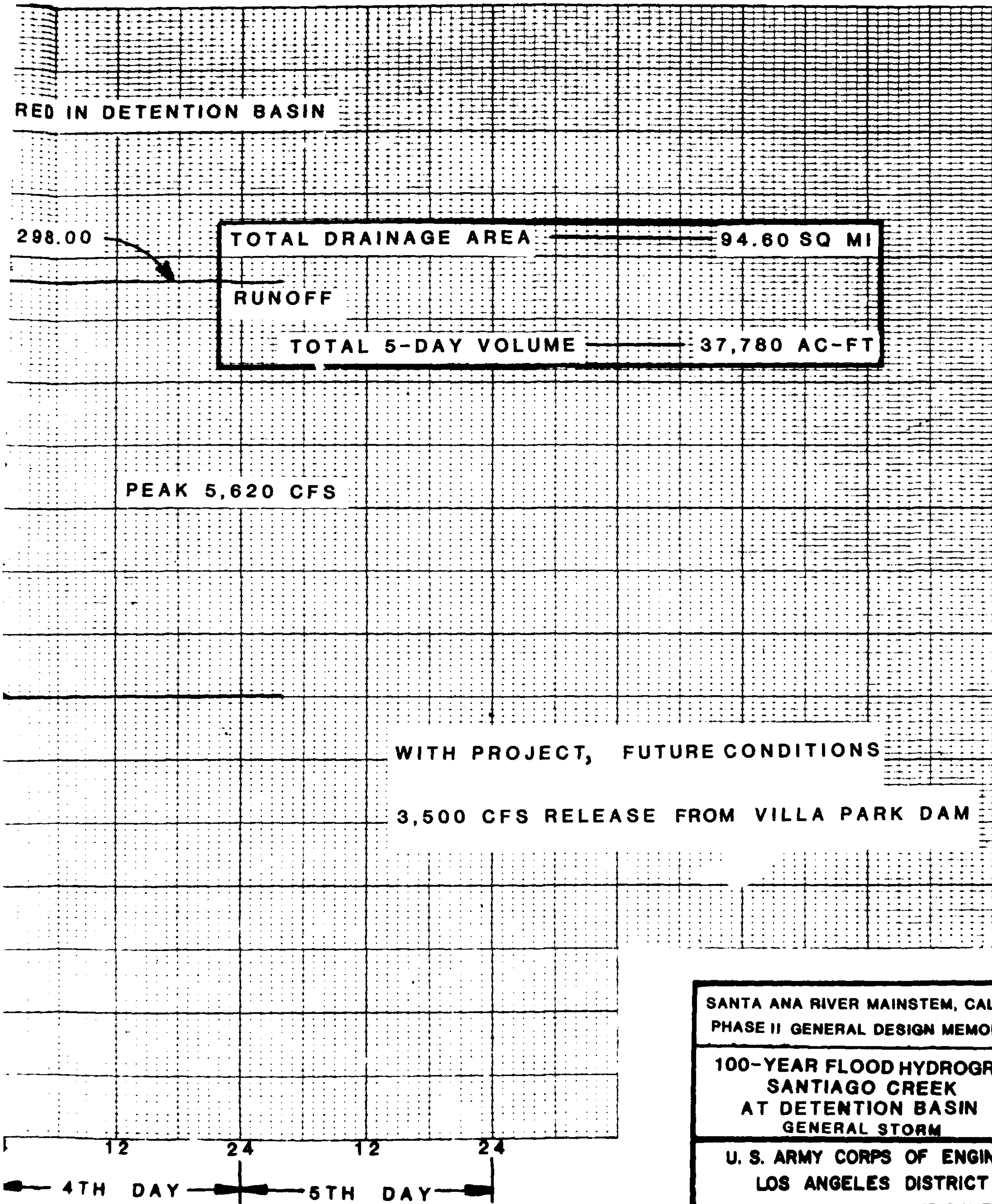
SANTIAGO CREEK DRAINAGE AREA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE-III-1



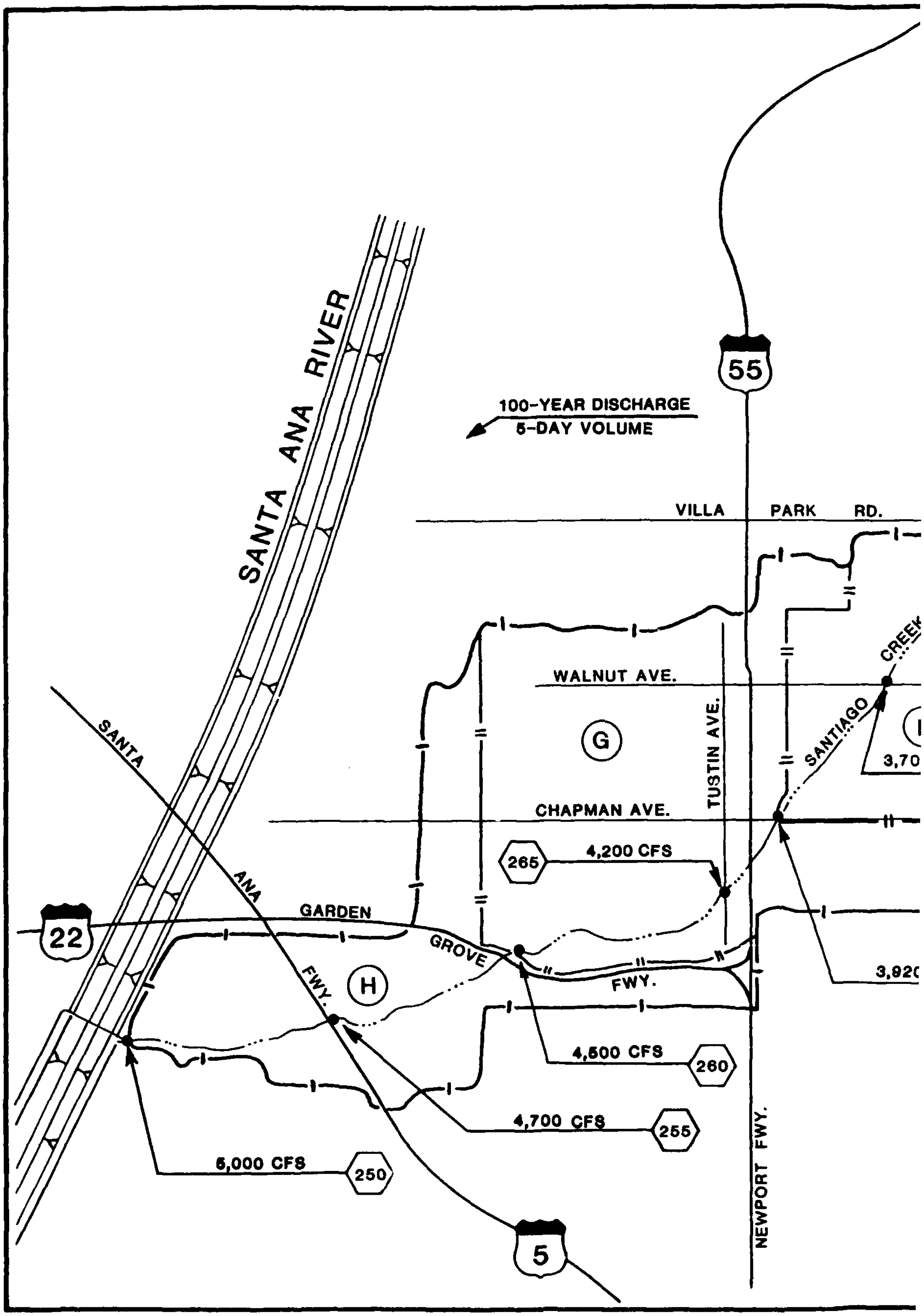
4,620 AC-FT OF RUNOFF STORED IN DET
MAX ALLOWABLE WATER SURFACE ELEVATIOM 298.00
300
290
280
270
ELEVATION IN FT
INFLOW
OUTFLOW
P
DISCHARGE IN CFS
5000
4000
3000
2000
1000
0
12
24
12
24
12
24
1ST DAY
2ND DAY
3RD DAY
4TH



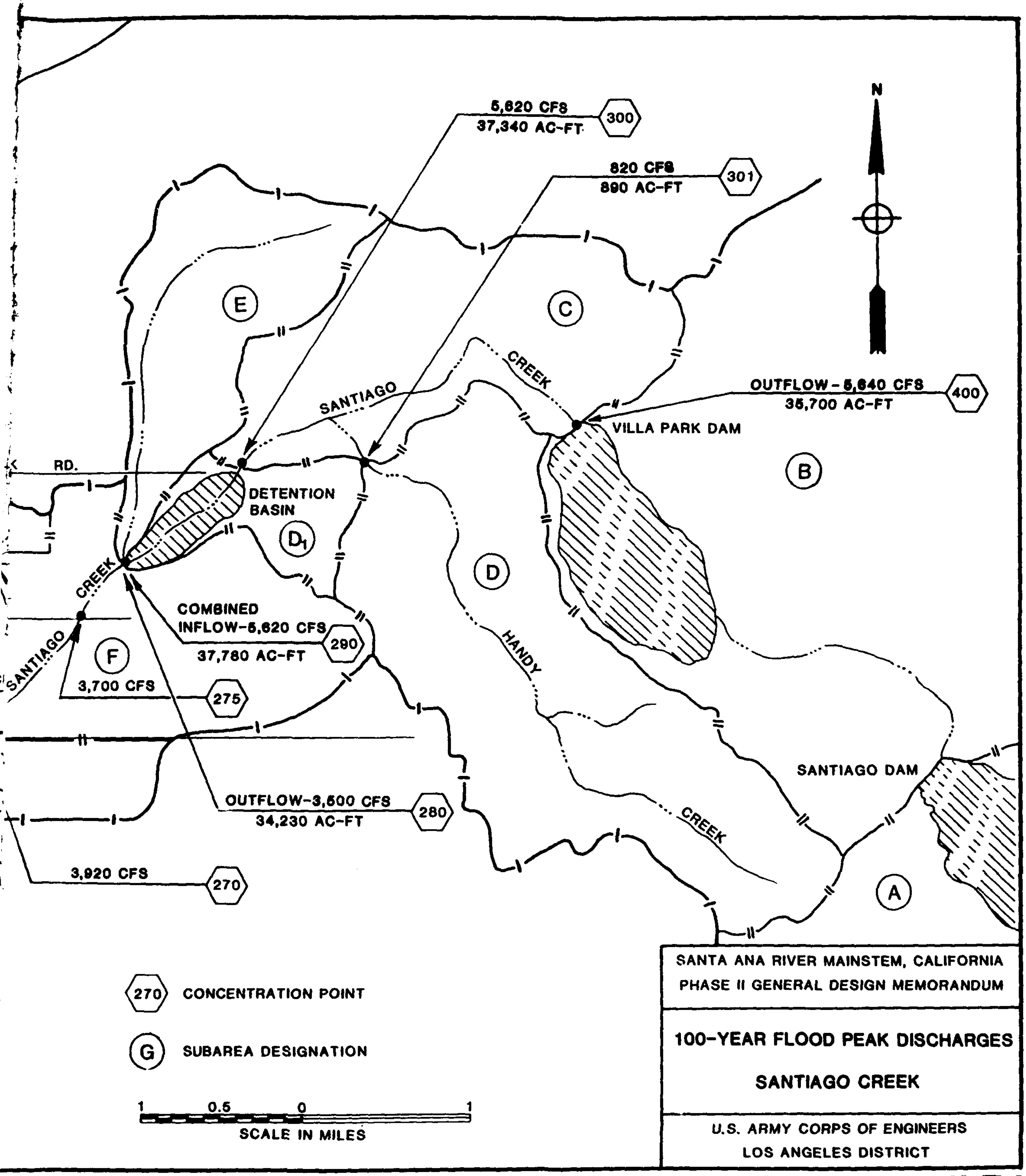
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

100-YEAR FLOOD HYDROGRAPH
SANTIAGO CREEK
AT DETENTION BASIN
GENERAL STORM

U. S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER
100-YEAR DISCHARGE
5-DAY VOLUME
55
VILLA PARK RD.
WALNUT AVE.
CREEK
SANTIAGO
G
TUSTIN AVE.
CHAPMAN AVE.
265
4,200 CFS
SANTA ANA FWY.
22
GARDEN GROVE FWY.
H
4,500 CFS
260
4,700 CFS
255
6,000 CFS
250
5
NEWPORT FWY.



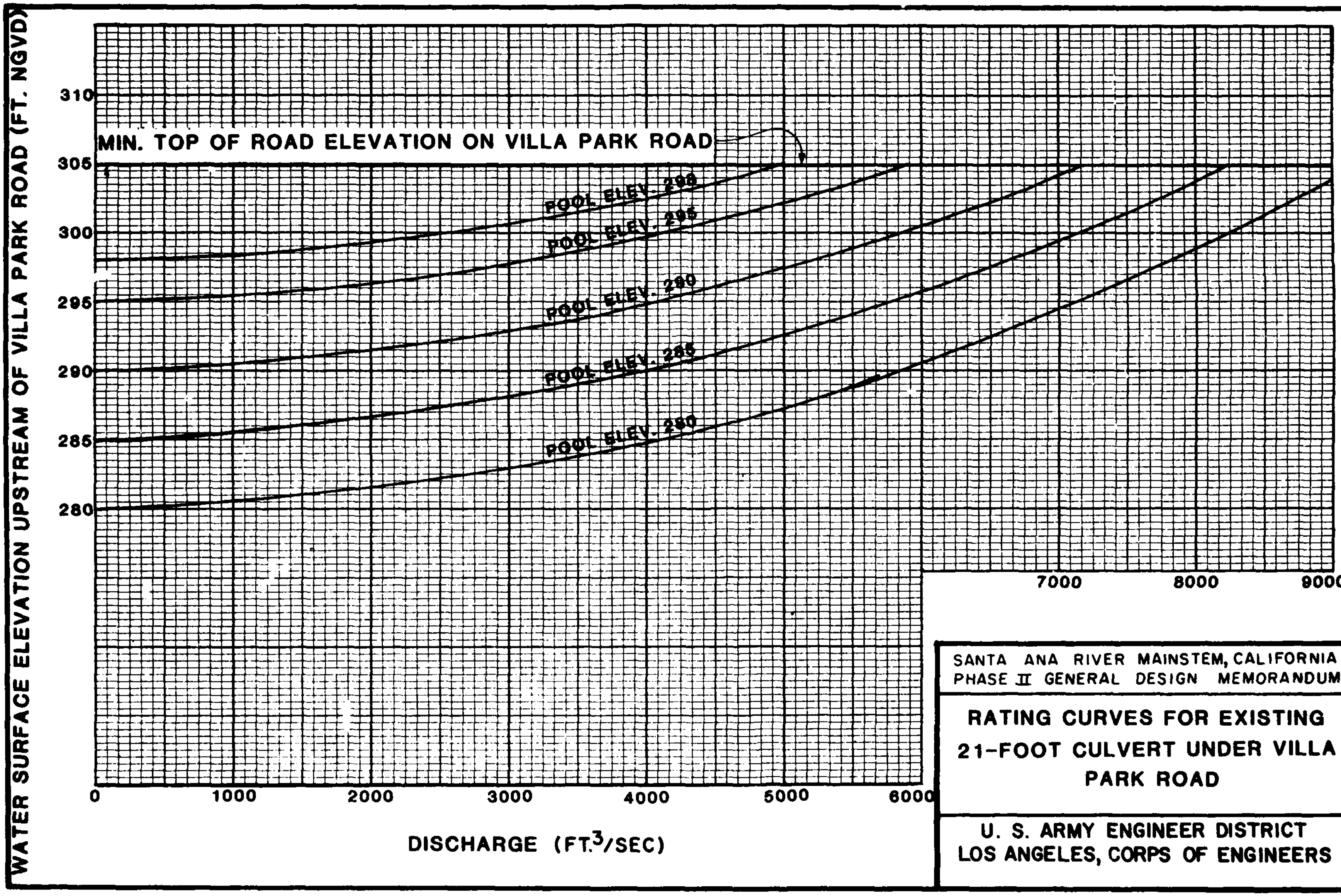
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

100-YEAR FLOOD PEAK DISCHARGES

SANTIAGO CREEK

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE-III-3

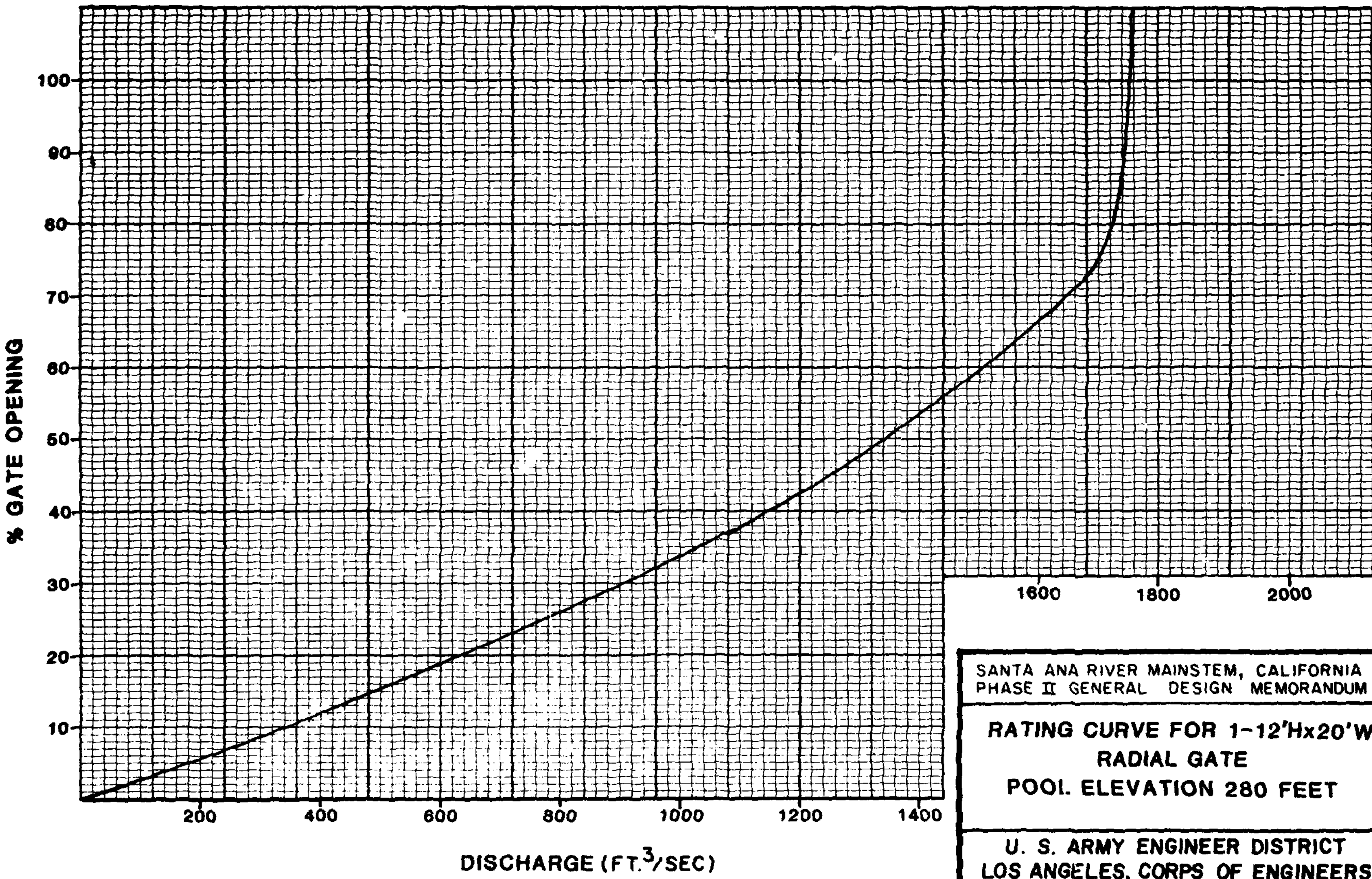


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

RATING CURVES FOR EXISTING 21-FOOT CULVERT UNDER VILLA PARK ROAD

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

FIGURE-IV-4

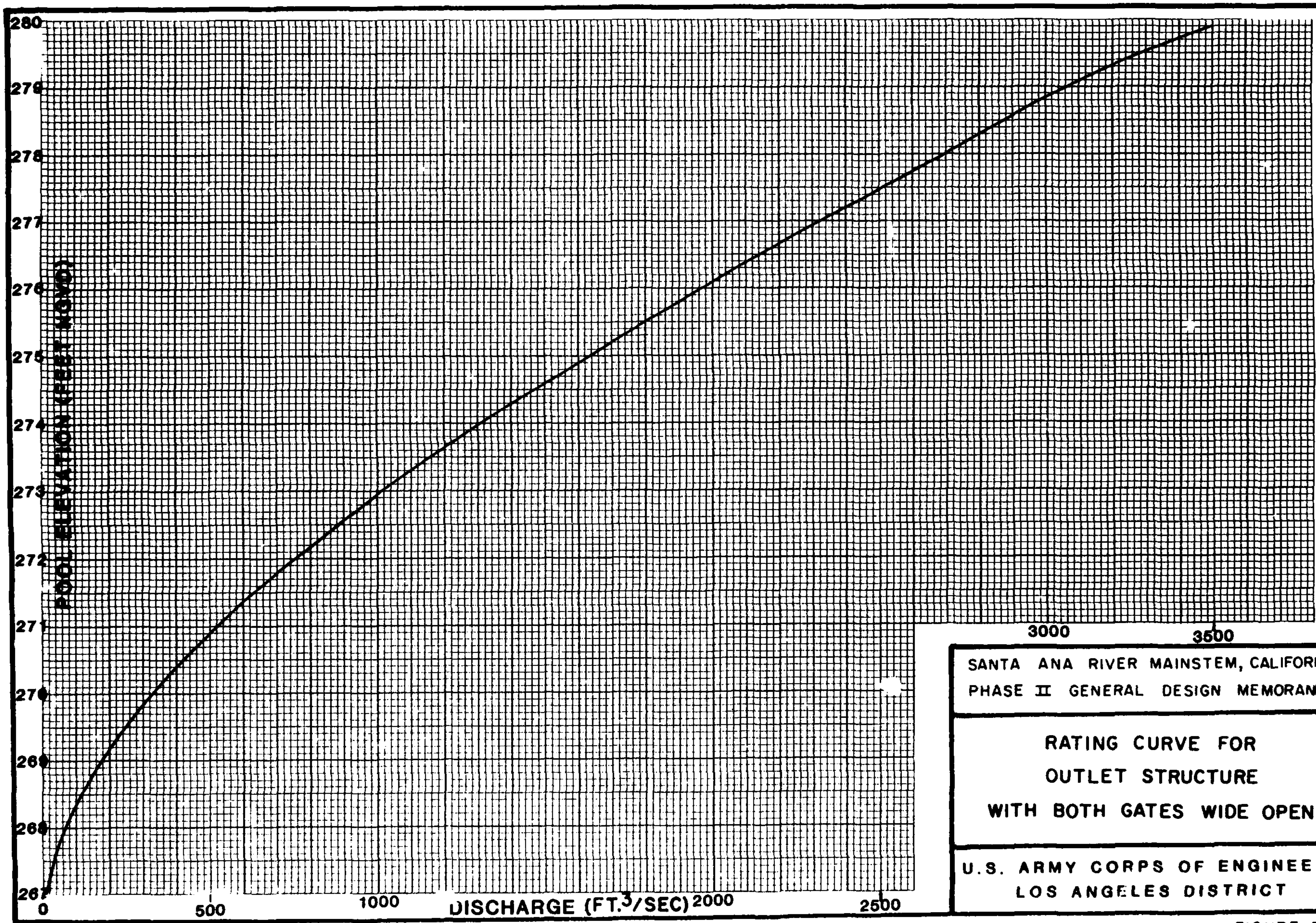


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

RATING CURVE FOR 1-12'Hx20'W RADIAL GATE
POOL ELEVATION 280 FEET

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

FIGURE-IV-5

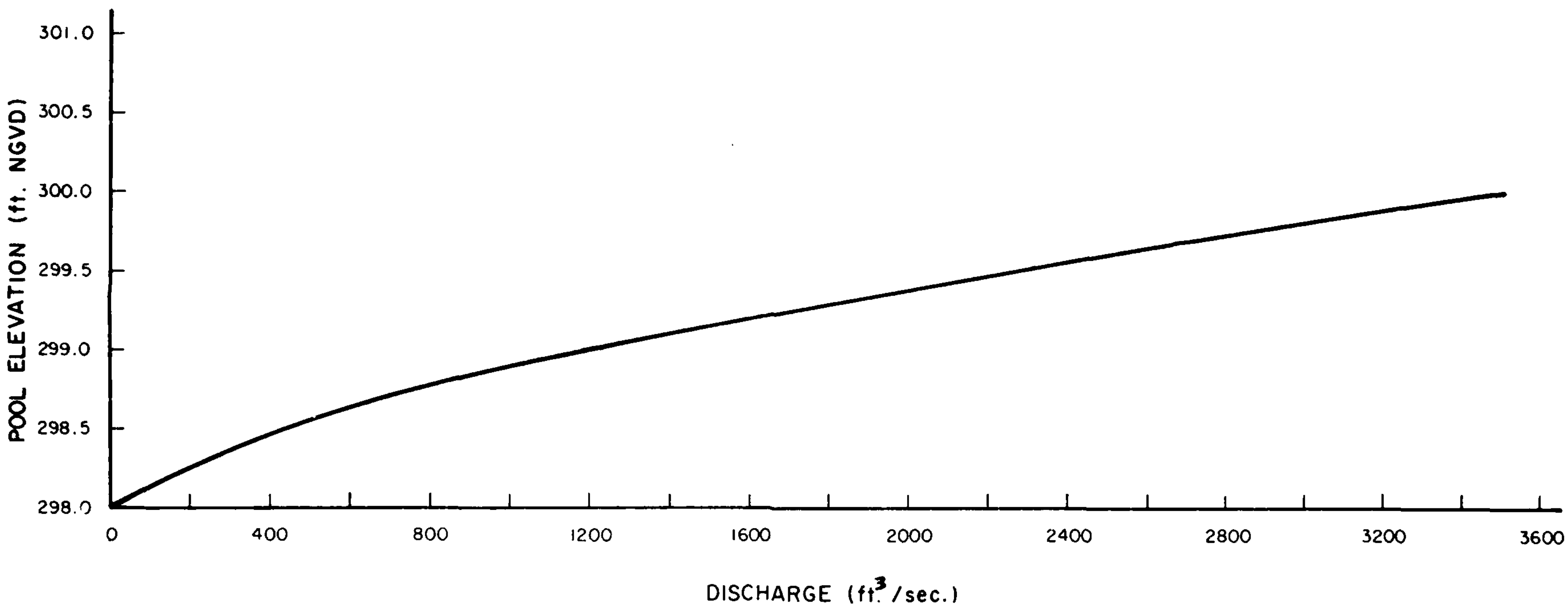


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

RATING CURVE FOR
OUTLET STRUCTURE
WITH BOTH GATES WIDE OPEN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE-IV-6

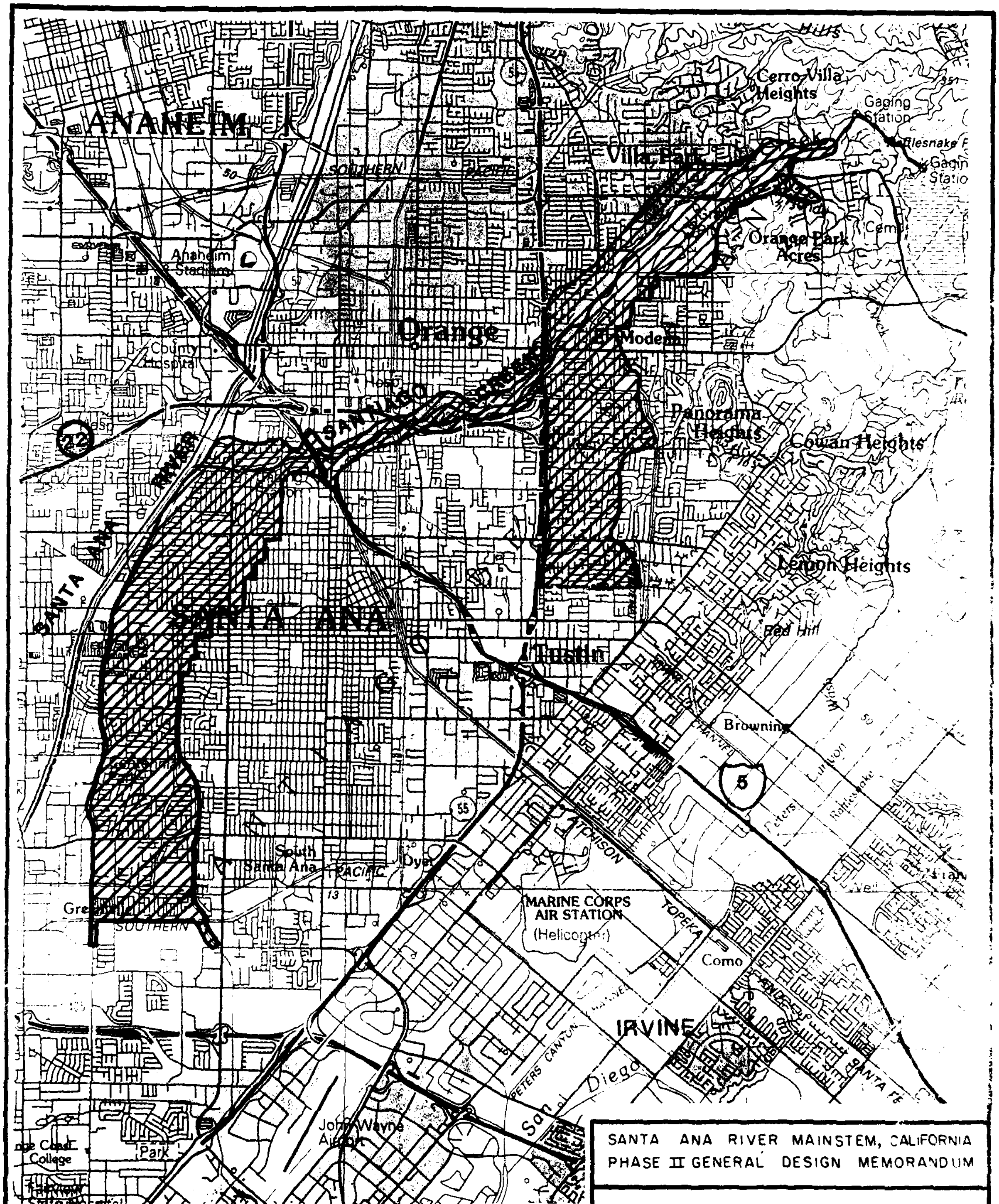


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

RATING CURVE FOR OVERFLOW STRUCTURE

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

FIGURE - IV-7



LEGEND : WITH-PROJECT STANDARD PROJECT FLOOD (250-YEAR FLOOD)

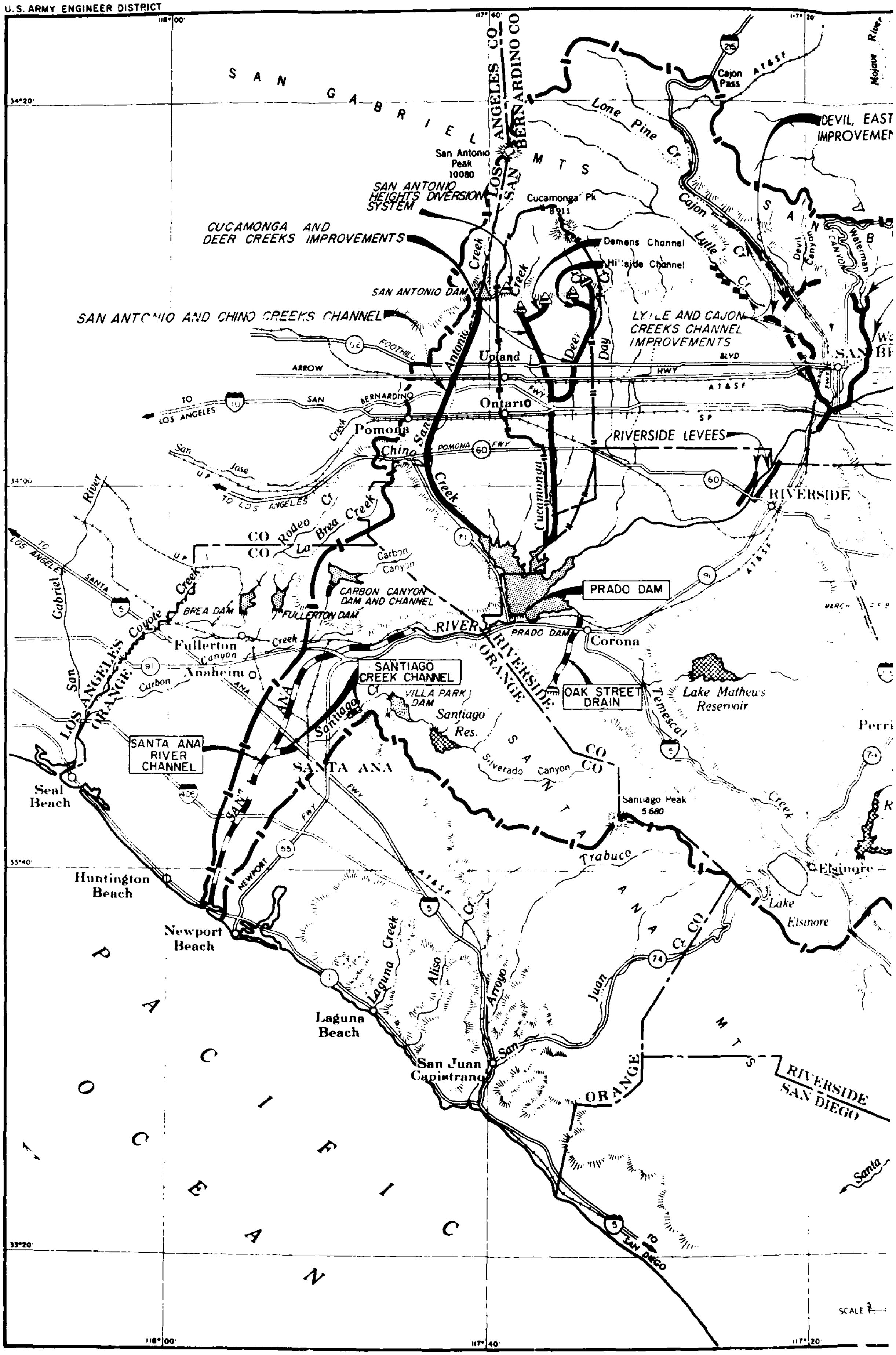
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

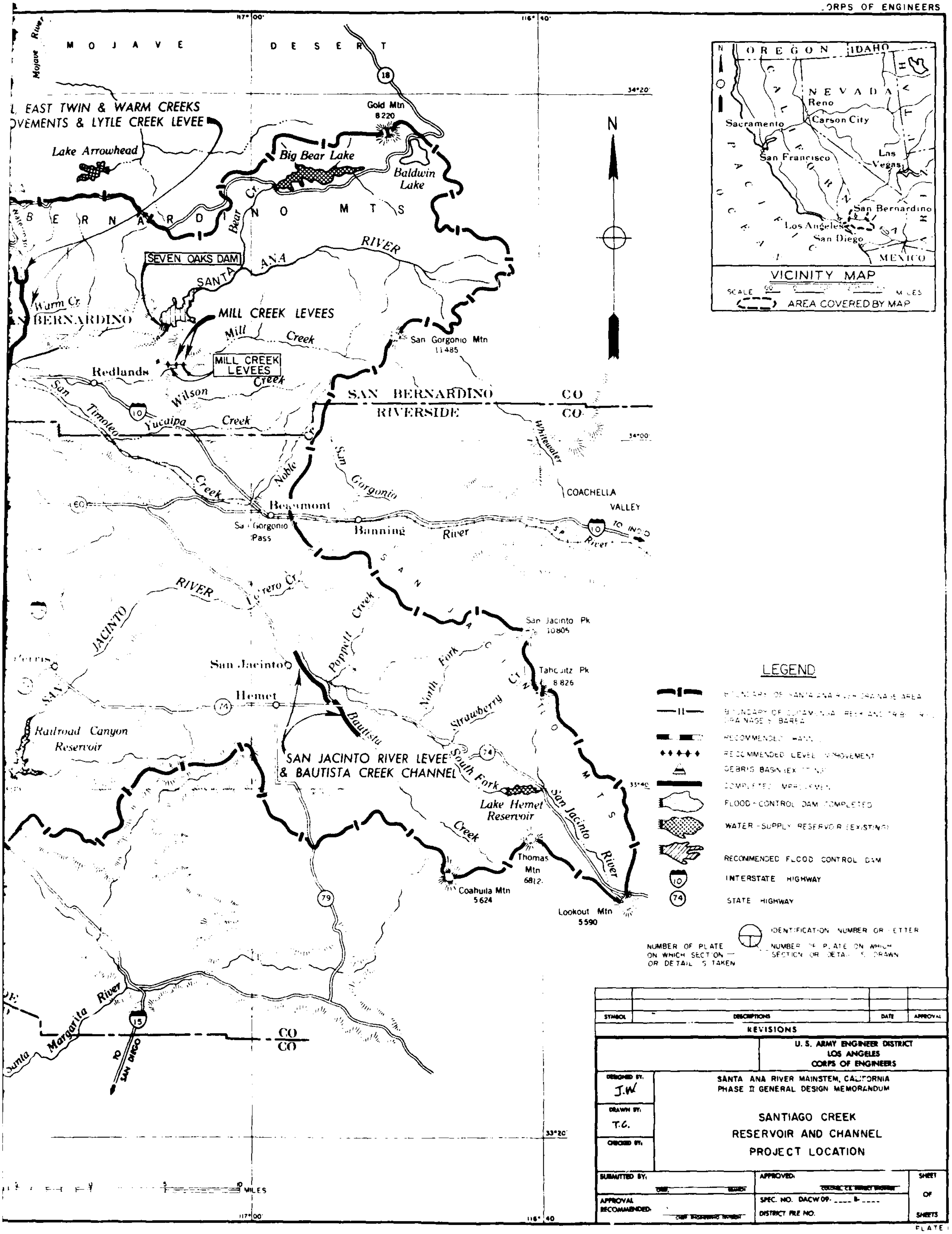
RESIDUAL OVERFLOWS

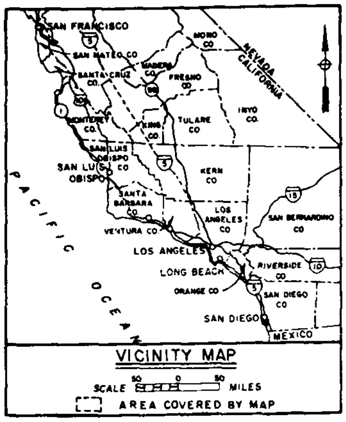
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED:

FIGURE-IV-8

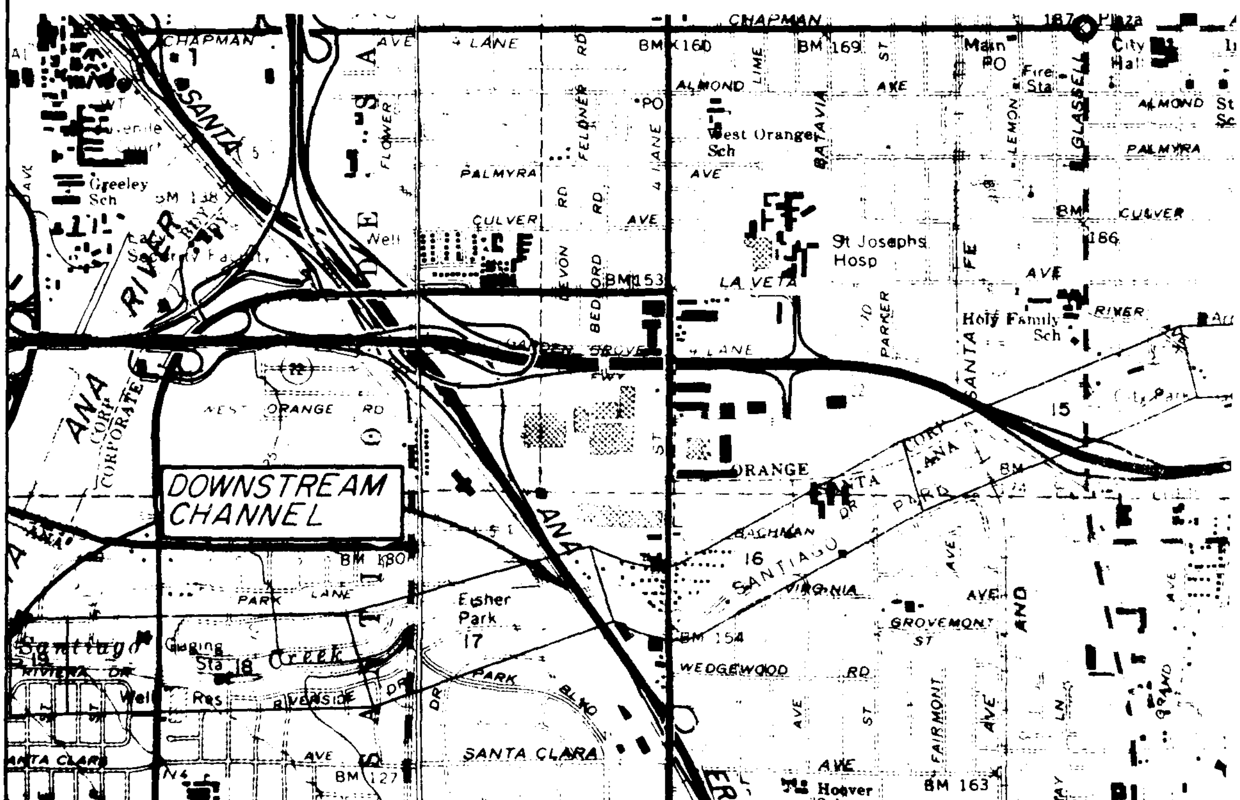
U.S. ARMY ENGINEER DISTRICT




CORPS OF ENGINEERS
MOJAVE DESERT
Mojave River
EAST TWIN & WARM CREEKS
IMPROVEMENTS & LYTLE CREEK LEVEE
Lake Arrowhead
Gold Mtn
8220
Big Bear Lake
Baldwin Lake
SAN BERNARDINO MTS
Bear Cr.
SEVEN OAKS DAM
SANTA ANA RIVER
Warm Cr.
SAN BERNARDINO
MILL CREEK LEVEES
Mill Creek
San Gorgonio Mtn
11485
Redlands
MILL CREEK LEVEES
Wilson Creek
San Timoteo Creek
Yucaipa Creek
SAN BERNARDINO CO
RIVERSIDE CO
Whitewater
Noble Cr.
San Gorgonio
COACHELLA VALLEY
Beaumont
San Gorgonio Pass
Banning
River
TO INDIO
RIVER
Potrero Cr.
SAN JACINTO MTS
SAN JACINTO
Poppet Creek
San Jacinto Pk
10805
Perris
San Jacinto
North Fork
Tahquitz Pk
8826
Hemet
Strawberry Cr.
Bautista
Railroad Canyon Reservoir
SAN JACINTO RIVER LEVEE & BAUTISTA CREEK CHANNEL
South Fork
Lake Hemet Reservoir
San Jacinto River
Creek
Thomas Mtn
6812
Coahuila Mtn
5624
Lookout Mtn
5590
Santa Margarita River
TO SAN DIEGO
CO
CO
MILES
117°00'
116°40'
34°20'
34°00'
33°40'
33°20'
N
OREGON IDAHO
NEVADA
Reno
Sacramento
Carson City
San Francisco
Las Vegas
San Bernardino
Los Angeles
San Diego
MEXICO
PACIFIC OCEAN
CALIFORNIA
VICINITY MAP
SCALE MILES
AREA COVERED BY MAP
LEGEND
RECOMMENDED CHANNEL
RECOMMENDED LEVEE IMPROVEMENT
DEBRIS BASIN (EXISTING)
FLOOD-CONTROL DAM COMPLETED
WATER-SUPPLY RESERVOIR (EXISTING)
RECOMMENDED FLOOD CONTROL DAM
INTERSTATE HIGHWAY
STATE HIGHWAY
IDENTIFICATION NUMBER OR LETTER
NUMBER OF PLATE ON WHICH SECTION OR DETAIL IS TAKEN
NUMBER OF PLATE ON WHICH SECTION OR DETAIL IS DRAWN
SYMBOL
DESCRIPTIONS
DATE
APPROVAL
REVISIONS
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
DESIGNED BY: J.W.
DRAWN BY: T.C.
CHECKED BY:
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
SANTIAGO CREEK
RESERVOIR AND CHANNEL
PROJECT LOCATION
SUBMITTED BY:
APPROVED:
APPROVAL RECOMMENDED:
SPEC. NO. DACW09-
DISTRICT FILE NO.
SHEET OF SHEETS
PLATE

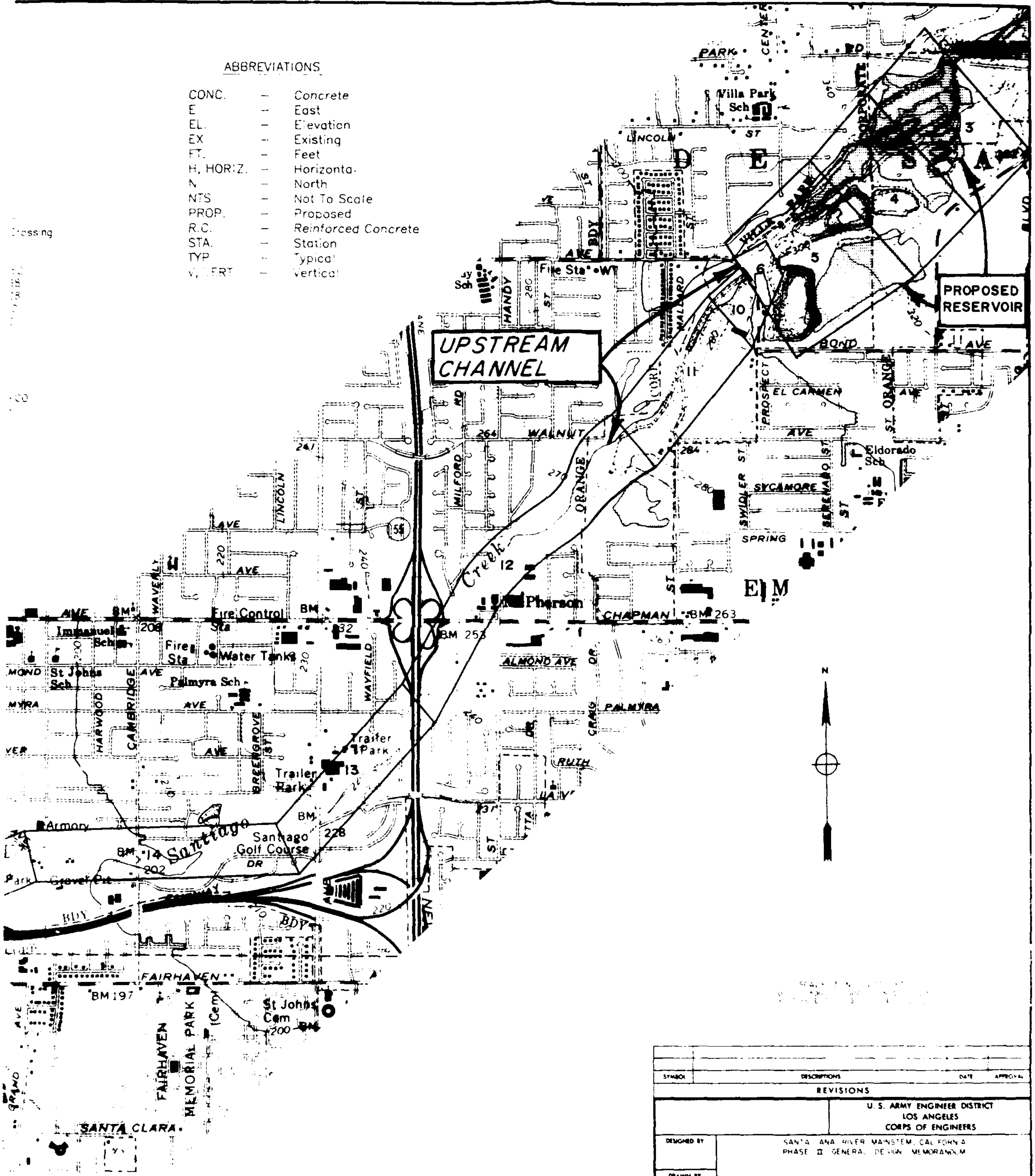

SAN FRANCISCO
SAN MATEO CO
SANTA CRUZ CO
MONTEREY CO
SAN LUIS OBISPO CO
SAN LUIS OBISPO
SANTA BARBARA CO
VENTURA CO
LOS ANGELES
LONG BEACH
ORANGE CO
SAN DIEGO
MEXICO
MONO CO
NEVADA
CALIFORNIA
MADERA CO
FRESNO CO
INYO CO
TULARE CO
KING CO
KERN CO
LOS ANGELES CO
SAN BERNARDINO CO
RIVERSIDE CO
SAN DIEGO CO
PACIFIC OCEAN
VICINITY MAP
SCALE MILES
AREA COVERED BY MAP

INDEX


CHAPMAN AVE
LANE
RD
BM 160
BM 169
CHAPMAN
Plaza
City Hall
Main PO
Fire Sta
ALMOND
AVE
GLASSELL
LEMON
PALMYRA
West Orange Sch
BATAVIA
Greeley Sch
SANTA ANA RIVER
FLOWER
FELDNER
CULVER
Well
St Josephs Hosp
LA VETA
PARKER
SANTA FE
Holy Family Sch
RIVER
BM 153
DEVON
BEDFORD
GARDEN GROVE FWY
WEST ORANGE RD
CORPORATE
DOWNSTREAM CHANNEL
ORANGE
BACHMAN
SANTIAGO
VIRGINIA
GROVEMONT ST
BM 180
PARK LANE
Fisher Park
17
16
15
BM 154
WEDGEWOOD RD
Santiago Creek
Gaging Sta
18
RIVIERA DR
Res
RIVERSIDE DR
PARK BLVD
SANTA CLARA
ANTA CLARA
AVE
BM 127
Hoover
BM 163
FAIRMONT
ST
AVE
LN

ABBREVIATIONS

CONC.	–	Concrete
E	–	East
EL.	–	Elevation
EX	–	Existing
FT.	–	Feet
H, HORIZ.	–	Horizontal
N	–	North
NTS	–	Not To Scale
PROP.	–	Proposed
R.C.	–	Reinforced Concrete
STA.	–	Station
TYP	–	Typical
V, VERT	–	Vertical



REVISIONS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: D. CASTRO

CHECKED BY:

SANTIAGO CREEK CHANNEL
GENERAL PLAN
AND INDEX

SUBMITTED BY:

DATE APPROVED:

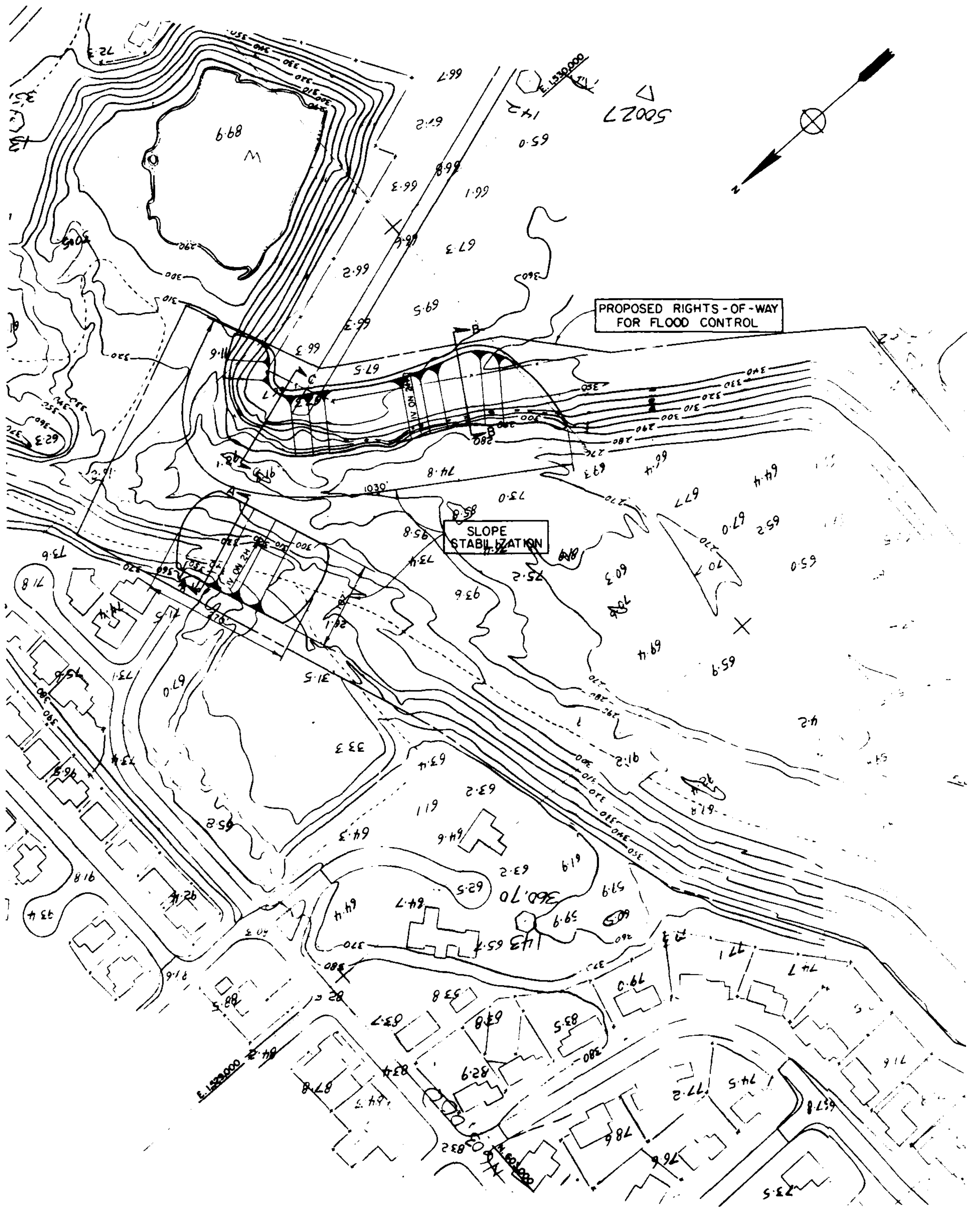
SPEC NO DACW09- ...

SHEET

DISTRICT FILE NO

PLATE 2

VALUE ENG

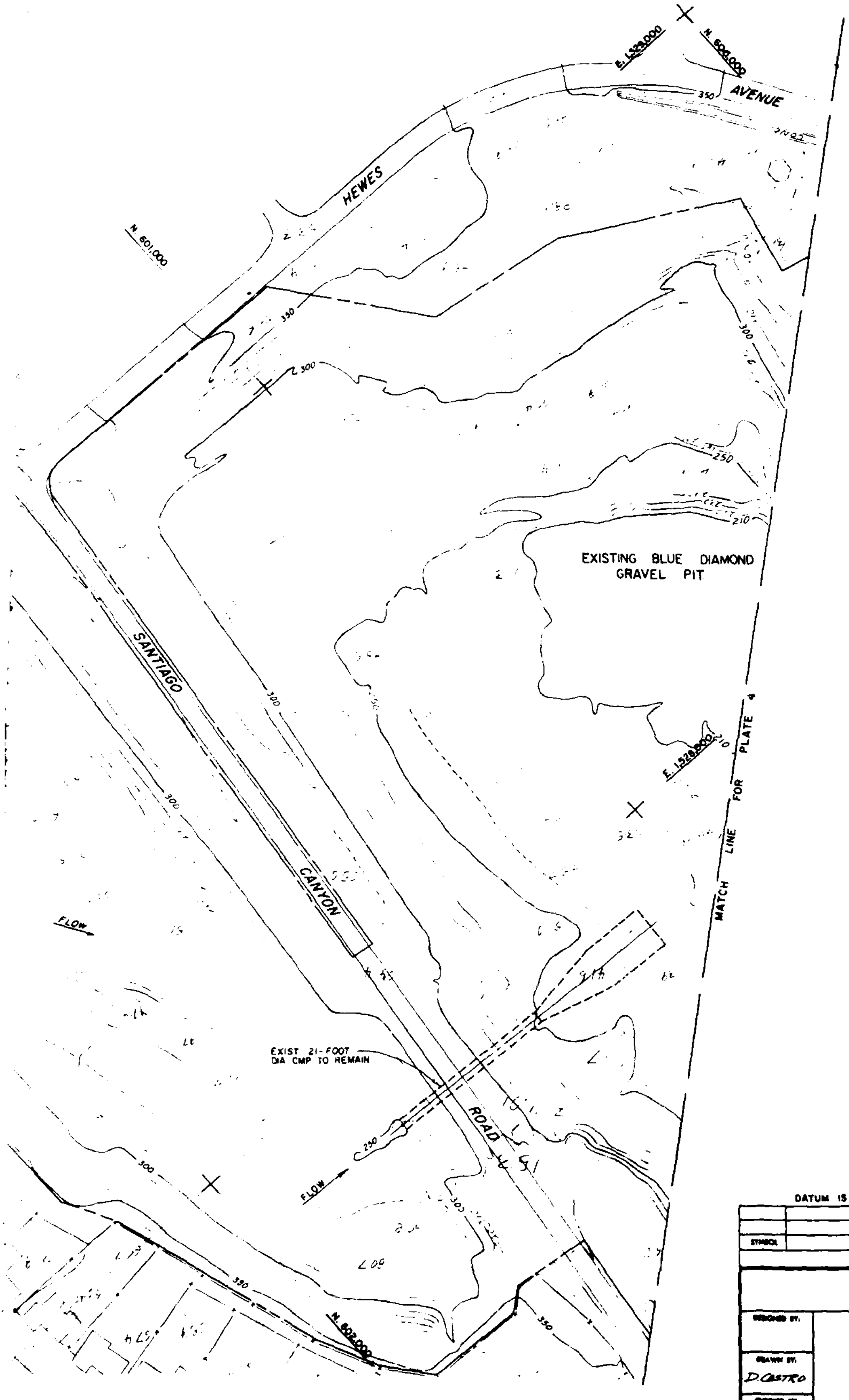


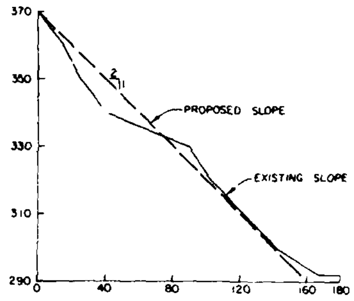
PLAN

SCALE

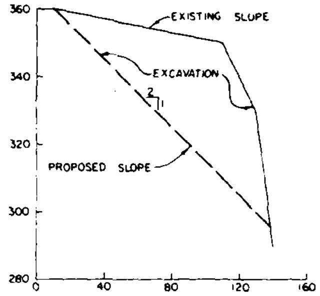
SAFE

ENGINEERING PAYS

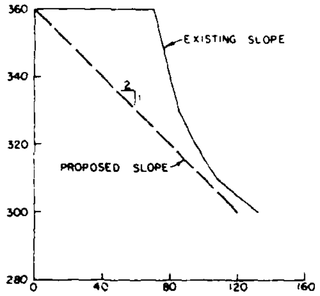




SECTION A-A
HORIZ SCALE 1IN=40 FT
VERT SCALE 1IN=20 FT



SECTION B-B
HORIZ SCALE 1IN=40 FT
VERT SCALE 1IN=20 FT



SECTION C-C
HORIZ SCALE 1IN=40 FT
VERT SCALE 1IN=20 FT

NOTE:

1 PROPOSED RIGHTS OF WAY FOR FLOOD CONTROL STORAGE REQUIRE BETWEEN ELEVATION 274 TO 300

200 300 FEET

SCALE 1 IN. = 20 FT

SCALE 1 IN. = 40 FT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: D. CASTRO

SANTIAGO CREEK RESERVOIR
GENERAL PLAN

CHECKED BY:

SUBMITTED BY:

DATE APPROVED:

SPEC. NO. DACW09-____-____

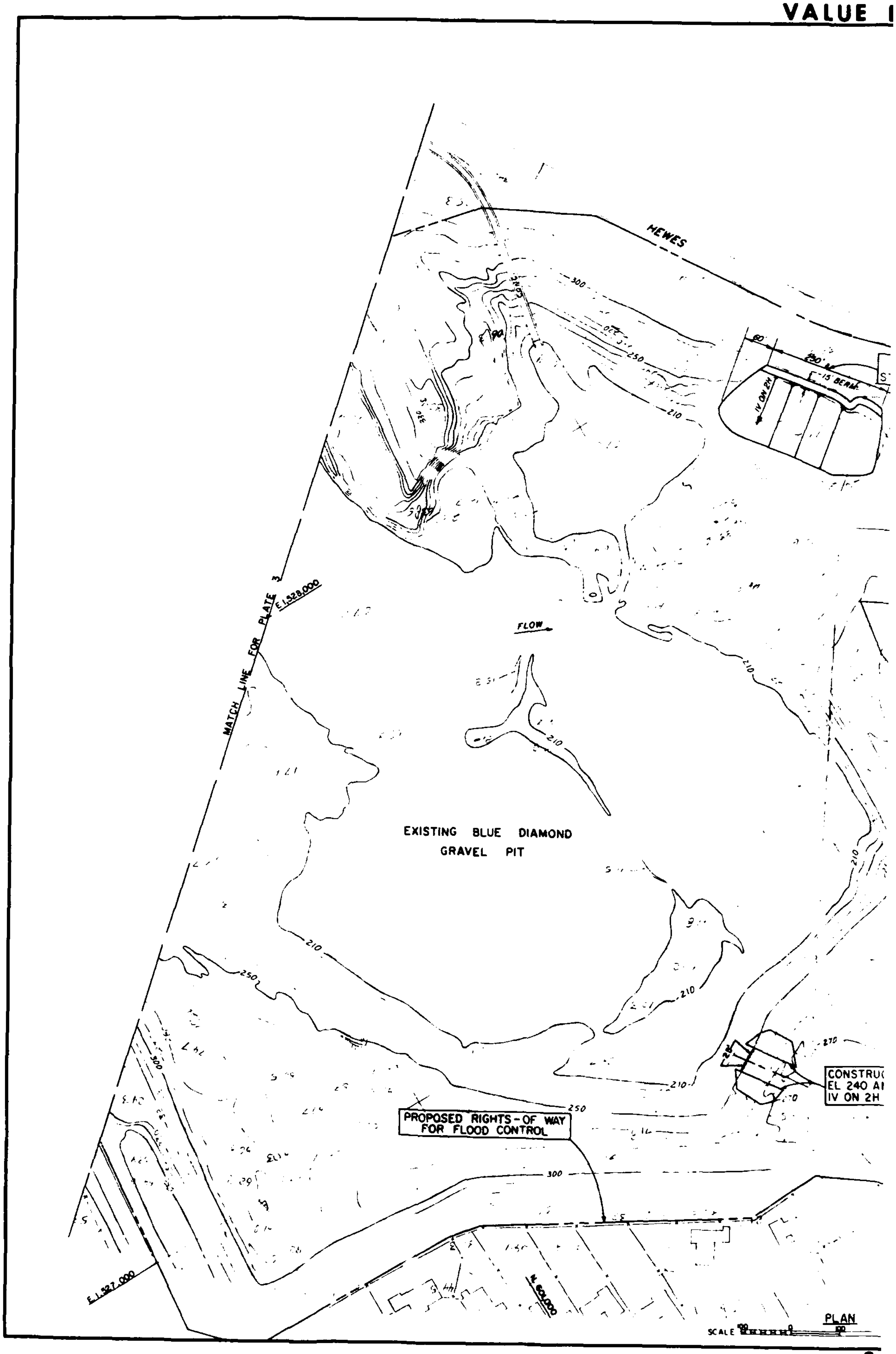
DISTRICT FILE NO.

SHEET 1 OF 3 SHEET

PLATE 3

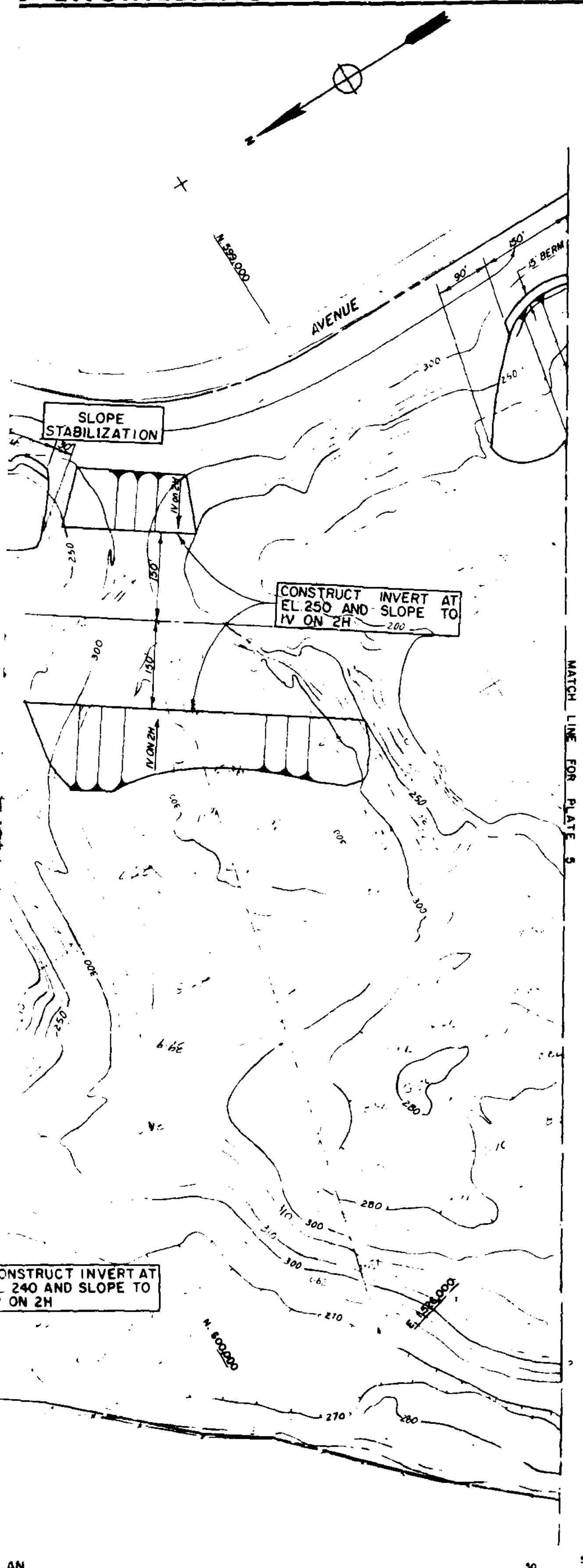
SAFETY PAYS

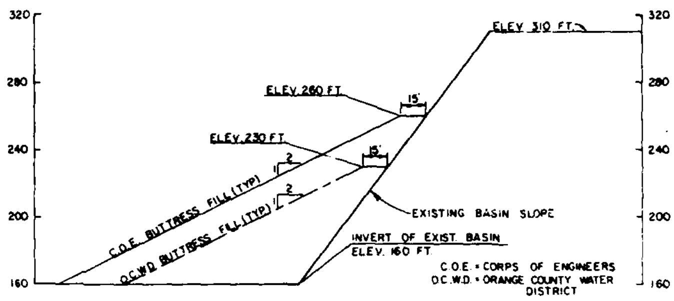
VALUE I



MATCH LINE FOR PLATE 3
E 1,528,000
HEWES
15' BERM
IV ON 2H
FLOW
EXISTING BLUE DIAMOND
GRAVEL PIT
300
250
210
270
PROPOSED RIGHTS-OF WAY
FOR FLOOD CONTROL
E 1,527,000
N 60,000
PLAN
SCALE

S





TYPICAL SECTION OF SLOPE STABILIZATION AT RESERVOIR

SCALE 1 IN = 40 FT

SCALE 1 IN = 40 FT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: D. CASTRO

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK RESERVOIR
GENERAL PLAN

SUBMITTED BY:

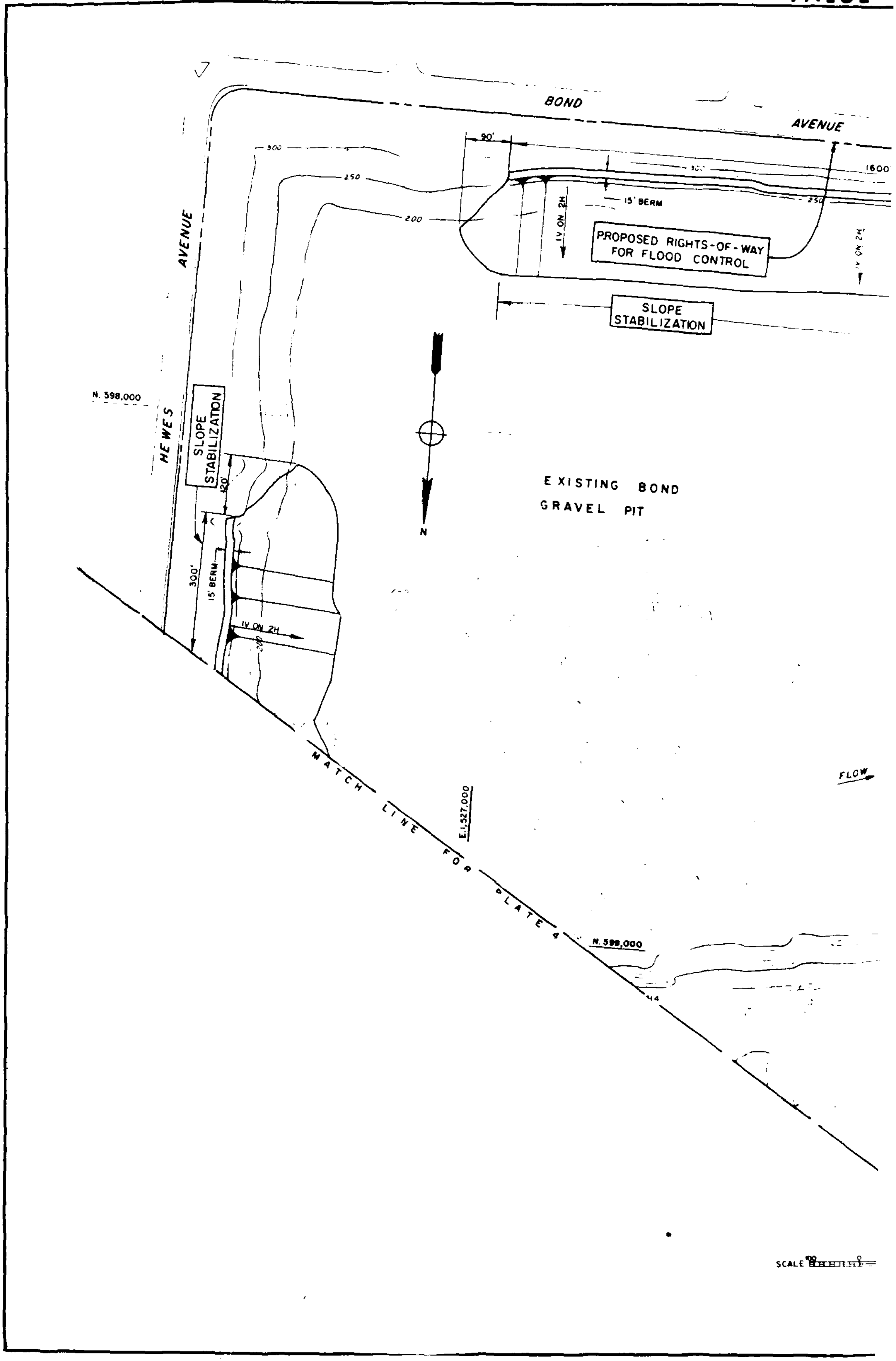
DATE APPROVED:

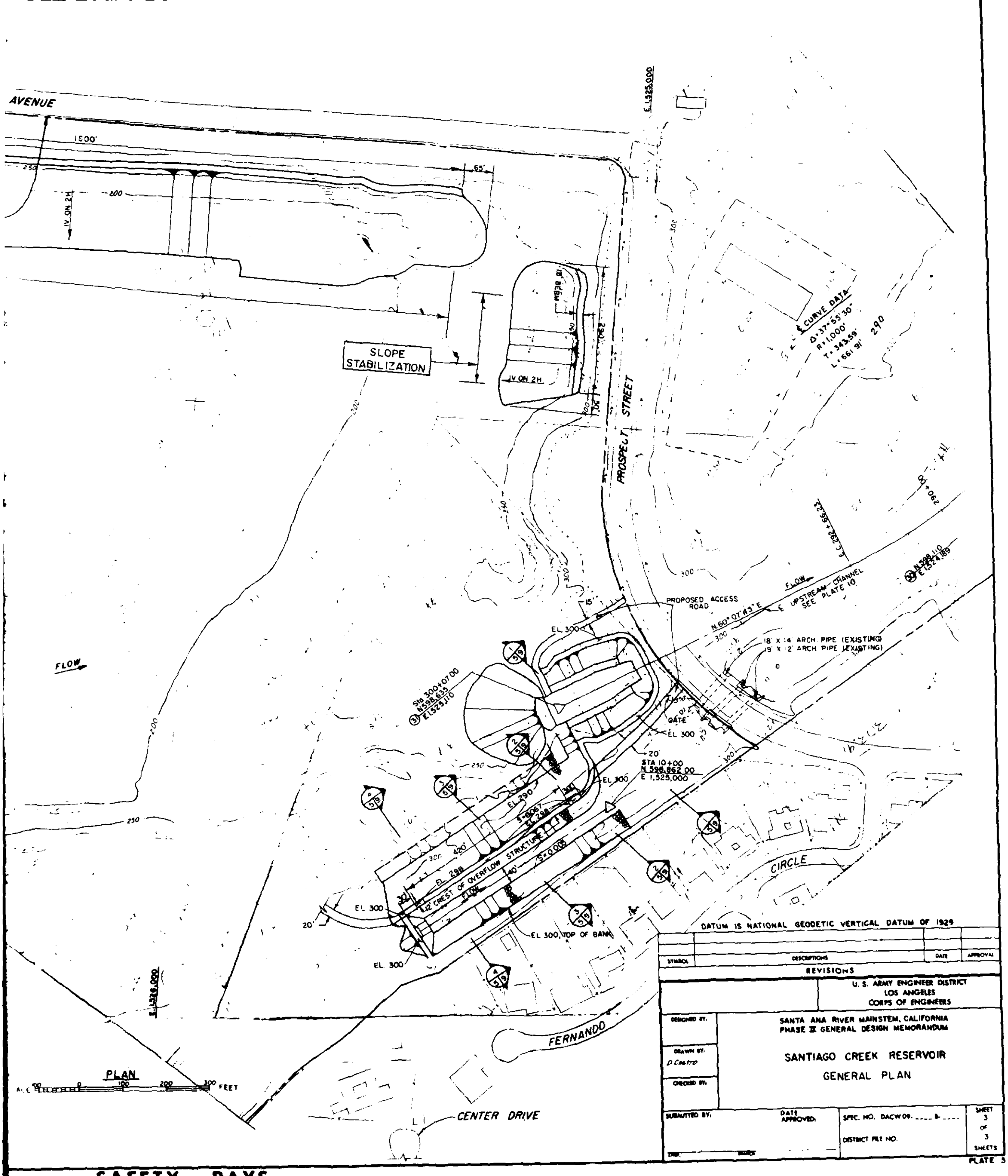
SPEC. NO. DACW09-____ B-____

DISTRICT FILE NO.

SHEET 2 OF 3 SHEETS

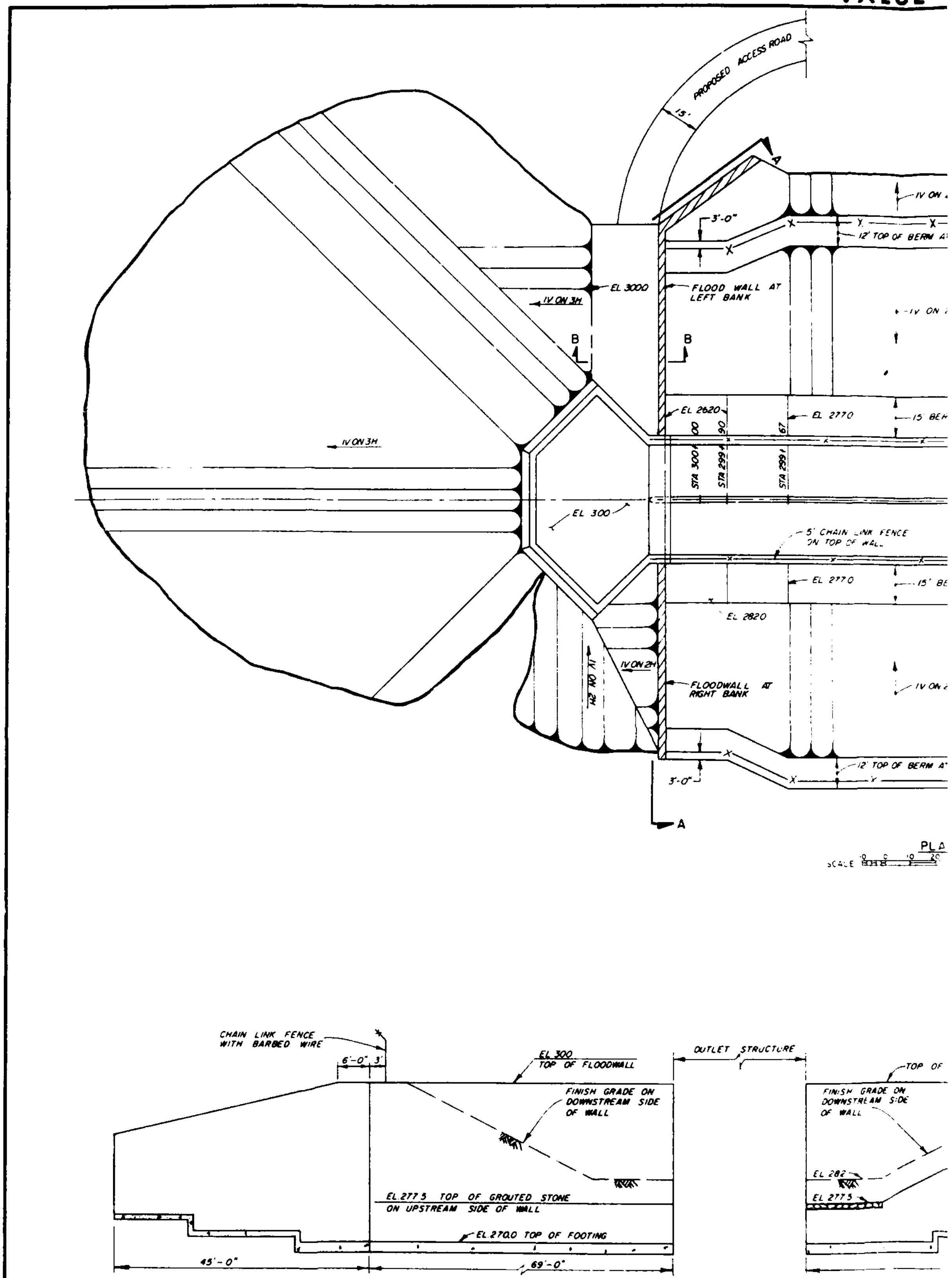
PLATE 4


BOND
AVENUE
HEWES
AVENUE
90'
15' BERM
1V ON 2H
PROPOSED RIGHTS-OF-WAY FOR FLOOD CONTROL
SLOPE STABILIZATION
SLOPE STABILIZATION
N. 598,000
120'
300'
15' BERM
1V ON 2H
EXISTING BOND GRAVEL PIT
N
MATCH LINE FOR PLATE 4
E.1,527,000
N. 599,000
FLOW
300
250
200
1600
SCALE



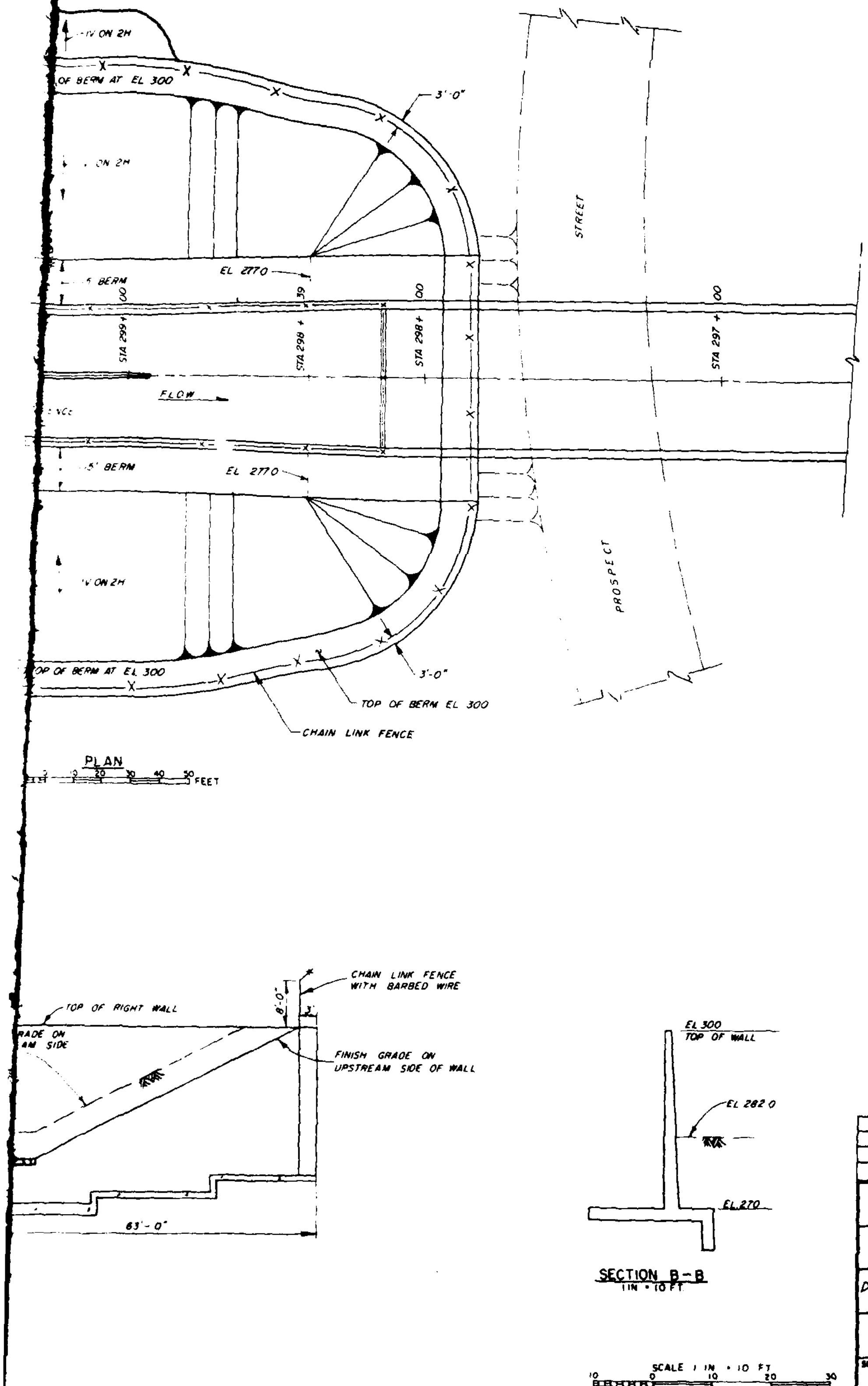
AVENUE
SLOPE STABILIZATION
PROSPECT STREET
CURVE DATA
Δ = 37°55'30"
R = 1,000'
T = 343.59'
L = 661.91'
PROPOSED ACCESS ROAD
UPSTREAM CHANNEL SEE PLATE 10
N 60°07'43" E
18' X 14' ARCH PIPE (EXISTING)
19' X 12' ARCH PIPE (EXISTING)
FLOW
GATE
STA 10+00
N 598,862.00
E 1,525,000
CREST OF OVERFLOW STRUCTURE
EL 300, TOP OF BANK
CIRCLE
FERNANDO
CENTER DRIVE
PLAN
FEET
DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929
REVISIONS
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
SANTIAGO CREEK RESERVOIR
GENERAL PLAN
DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-
DISTRICT FILE NO.
SHEET 3 OF 3 SHEETS
PLATE 5

VALUE



SECTION A-A
1 IN = 10 FT

S



SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: D CASTRO

CHECKED BY:

SANTIAGO CREEK RESERVOIR
OUTLET STRUCTURE
PLAN AND SECTIONS

SUBMITTED BY:

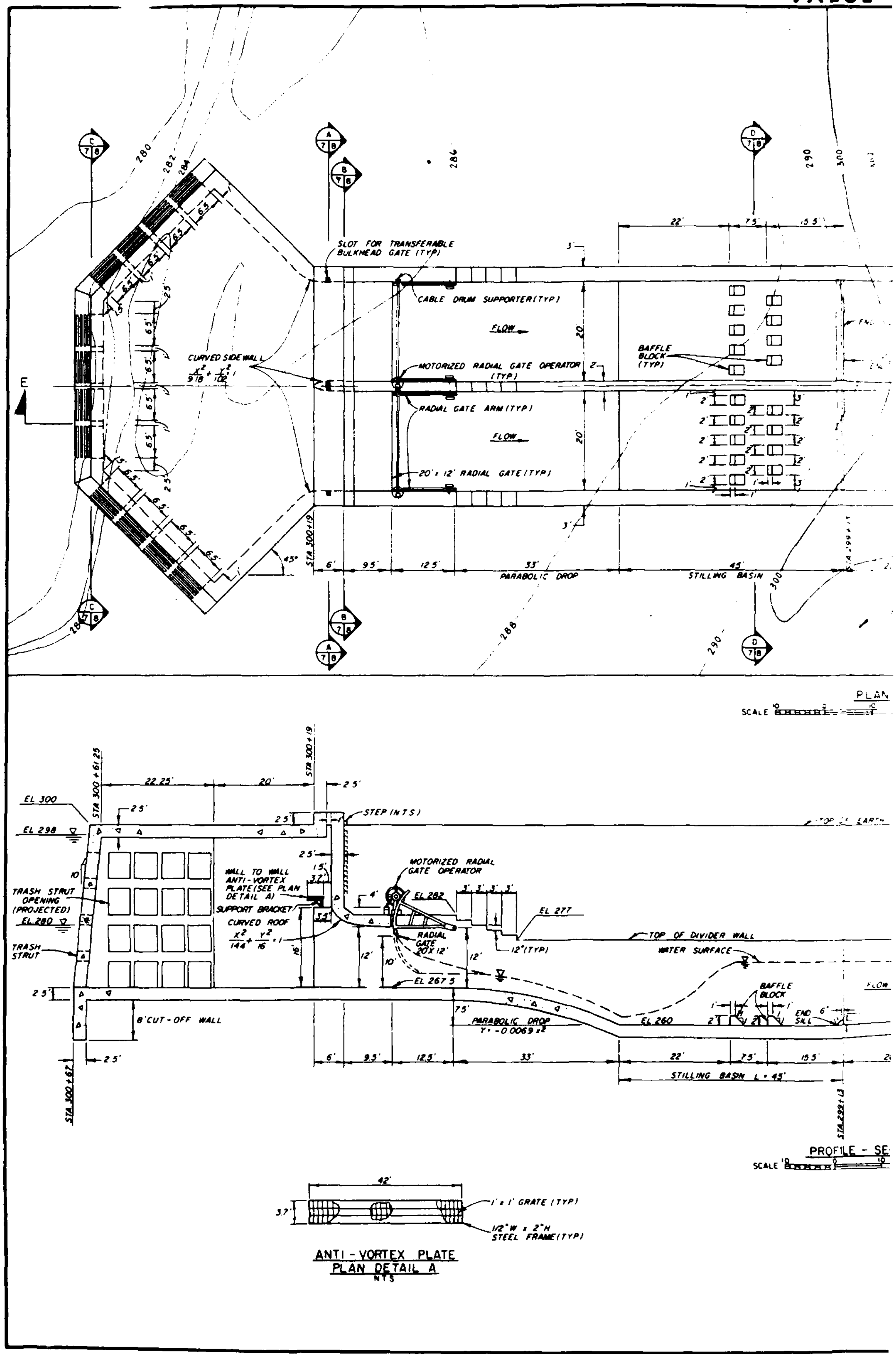
DATE APPROVED:

SPEC. NO. DACW09-___-B-___

SHEET

DISTRICT FILE NO

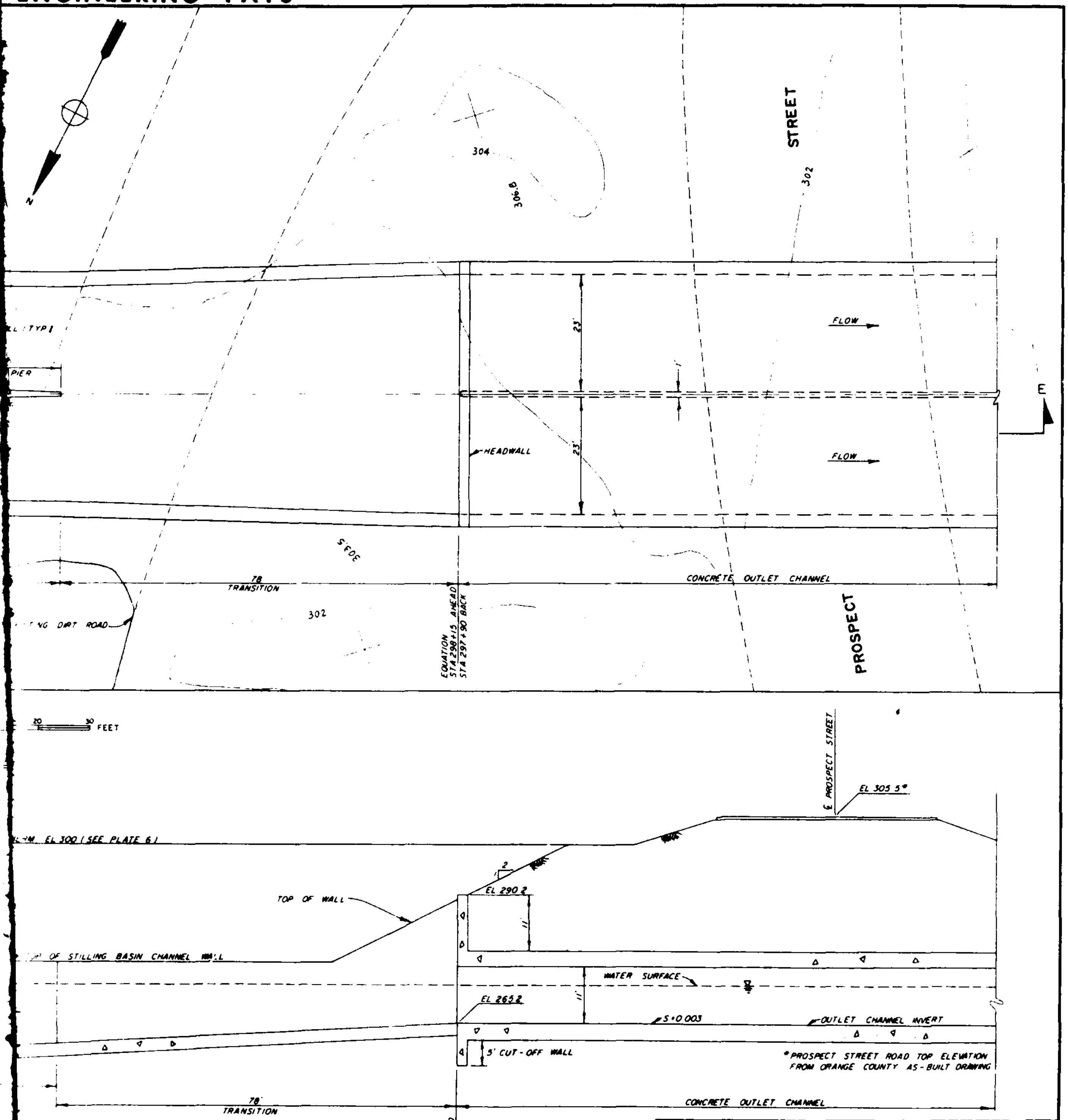
VALUE



ANTI-VORTEX PLATE PLAN DETAIL A
NTS

S

ENGINEERING PAYS



NOTE.

1. A SINGLE TRANSFERABLE BULKHEAD GATE IS REQUIRED FOR FLOOD CONTROL
2. THE SUMMARY TABLE OF HYDRAULIC ELEMENTS FOR THE OUTLET STRUCTURE IS DISPLAYED IN THE REPORT TEXT ON PAGE IV-8, TABLE IV-1

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY.
DRAWN BY.
CHECKED BY.

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

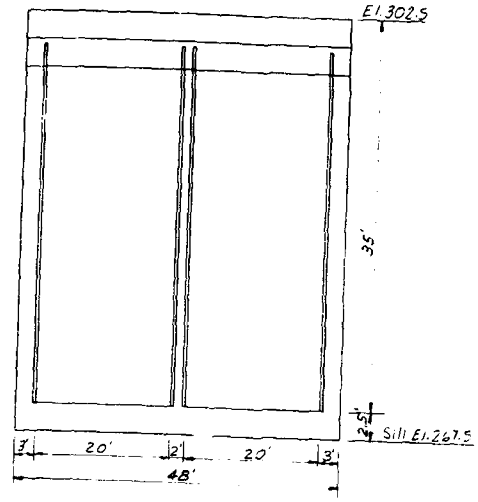
SANTIAGO CREEK RESERVOIR
OUTLET STRUCTURE
PLAN AND PROFILE

SUBMITTED BY.
DATE APPROVED.
SPEC. NO. DACW09-____ B-____
DISTRICT FILE NO.
SHEET 1 OF 1 SHEETS

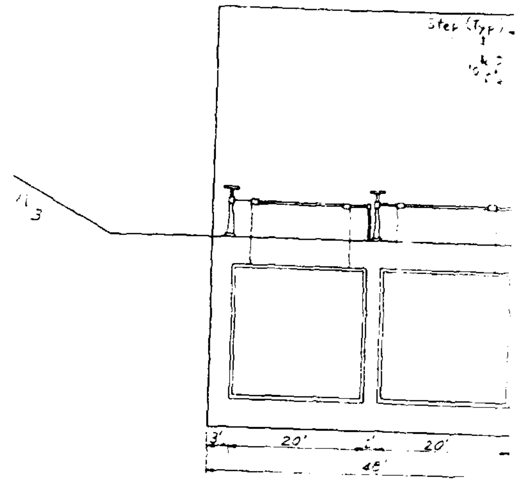
PLATE 7

FETY PAYS

VALUE E

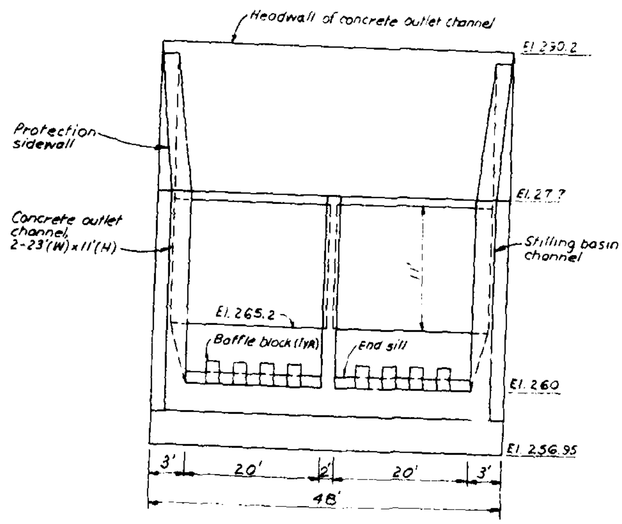


SECTION (A 7|8)
HORIZ SCALE 1 IN = 10 FT
VERT SCALE 1 IN = 6 FT

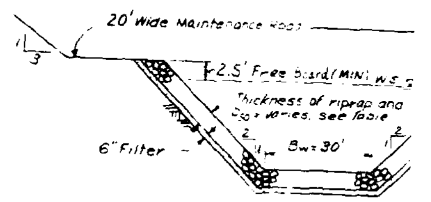


SECTION (B 7|8)
RADIAL GATE ASSESSORY
HORIZ SCALE 1 IN = 10 FT
VERT SCALE 1 IN = 6 FT

NOTE: When gate is in the full open p
the opening w be 'C' Horizo

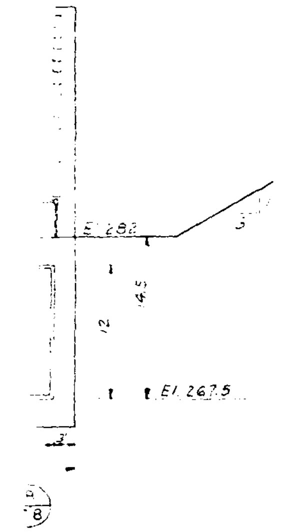


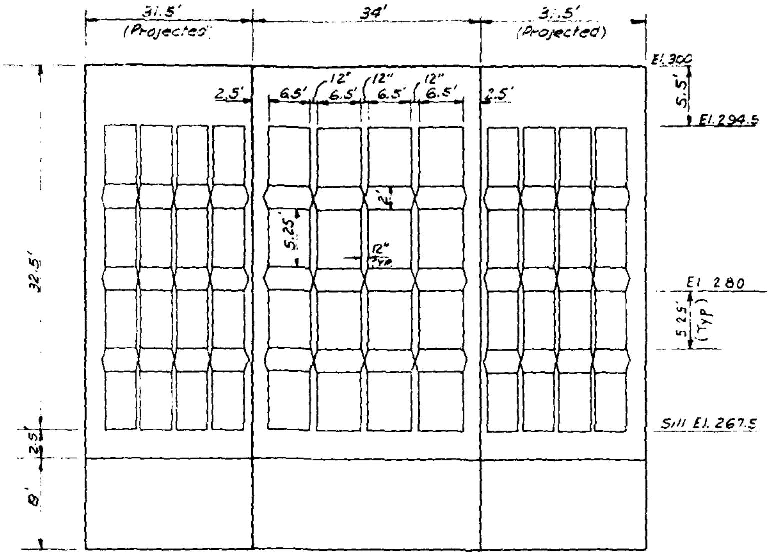
SECTION (D 7|8)
STILLING BASIN CHANNEL
HORIZ. SCALE 1 IN = 10 FT
VERT SCALE 1 IN = 6 FT



TYPICAL SECTION OF RIPRAP CHANNEL
STA 292+85 TO STA 252+00
NOT TO SCALE

SAF

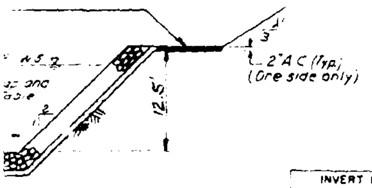


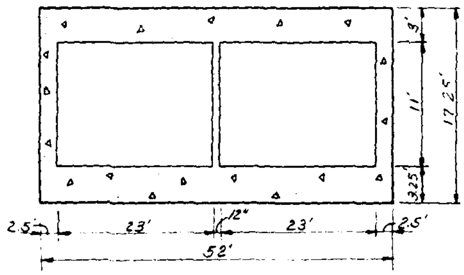


SECTION (C/7|8)
TRASH STRUT
HORIZ. SCALE: 1 IN. = 10 FT
VERT. SCALE: 1 IN. = 6 FT

NOTE: *Upstream edge of all vertical and Horizontal members and all outside edges to be semi-circular.*

...en position
...rizontal Typ.

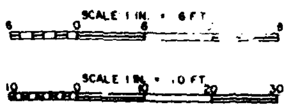




TYPICAL BOX SECTION
(STA. 297+90 TO STA. 295+90)
HORIZ. SCALE: 1 IN. = 10 FT.
VERT. SCALE: 1 IN. = 6 FT.

	STA. 292+85 TO STA. 254+00	STA. 254+00 TO STA. 252+00
INVERT LAYER THICKNES	12"	12" GROUTED ROCK
D_{50} (MAX)	8"	-
SIDE SLOPE LAYER THICKNESS	12"	-
D_{50} (MAX)	8"	-

HANNEL (E/10|8)
00



SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

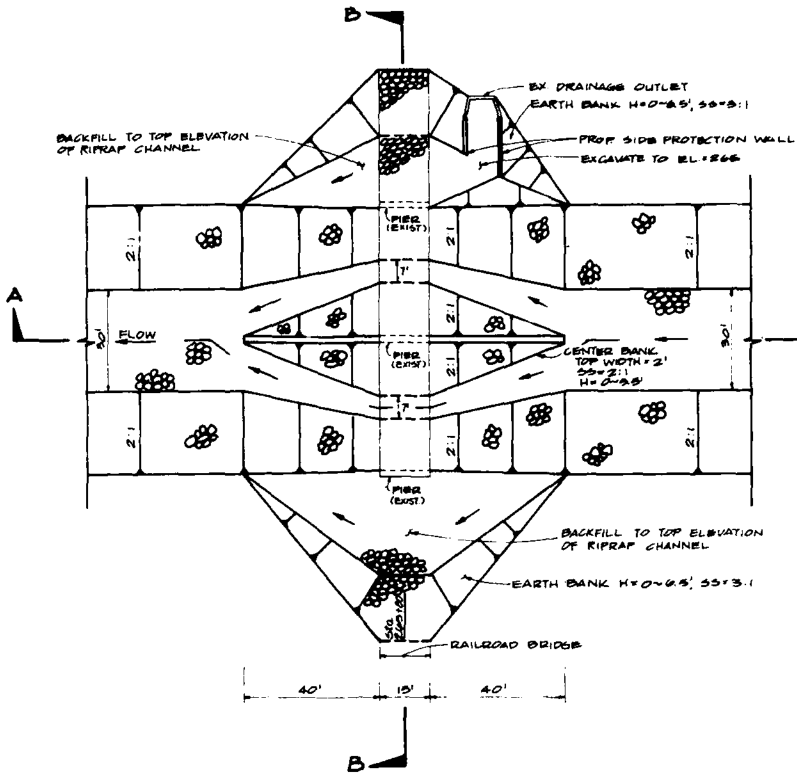
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: N. M.
CHECKED BY:

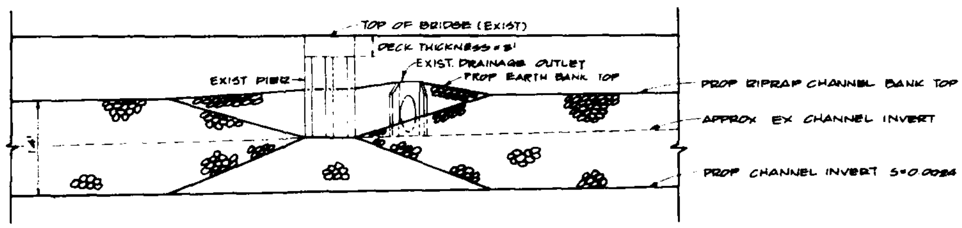
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK RESERVOIR
OUTLET STRUCTURE DETAIL
AND TYPICAL CHANNEL SECTION

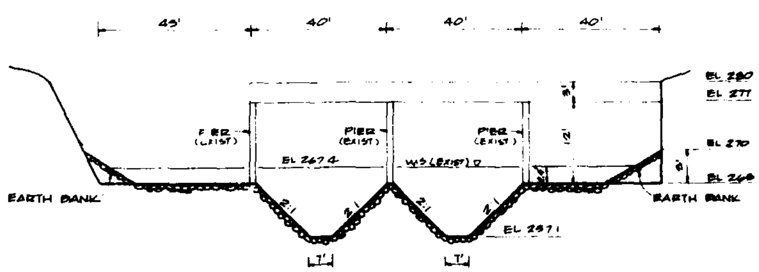
SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____-B-____
DISTRICT FILE NO.
SHEET 1 OF 1 SHEETS



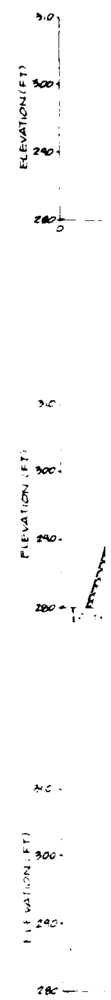
PLAN
SCALE 1"=20'

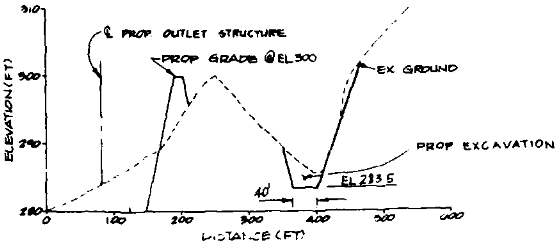


SECTION A-A
SCALE: HORIZ 1"=20'
VERT 1"=10'

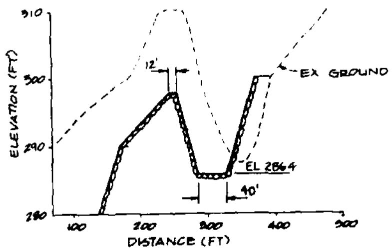


SECTION B-B
SCALE: HORIZ 1"=20'
VERT 1"=10'

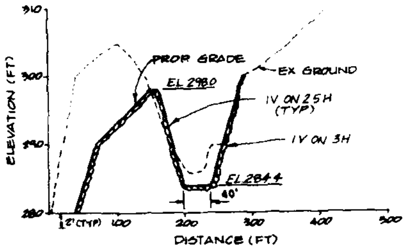




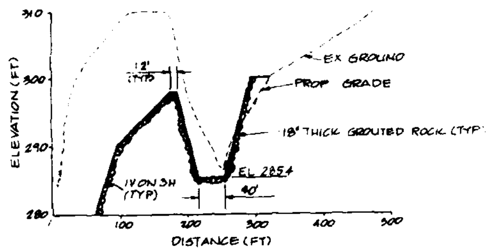
SECTION 1 / 5 | 9
SCALE HORIZ 1" = 100'
VERT 1" = 10'



SECTION 4 / 5 | 9
SCALE HORIZ 1" = 100'
VERT. 1" = 10'



SECTION 2 / 5 | 9
SCALE: HORIZ 1" = 100'
VERT 1" = 10'



SECTION 3 / 5 | 9
SCALE HORIZ 1" = 100'
VERT 1" = 10'

SCALE 1 IN = 10 FT

SCALE 1 IN = 100 FT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

Sheng, Li & Associates, Inc.

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

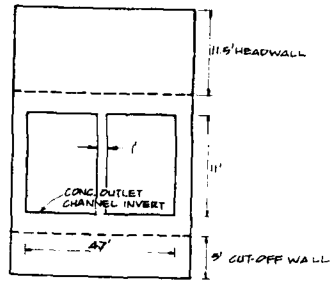
DESIGNED BY: STL
DRAWN BY: EC
CHECKED BY: WSL

SANTIAGO CREEK RESERVOIR-CHANNEL
DETAILS OF OVERFLOW STRUCTURE
AND BRIDGE CROSSING

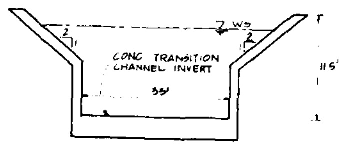
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____ B-____ | SHEET 1 OF 1 SHEETS
DISTRICT FILE NO.

PLATE 9

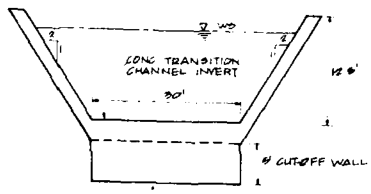
VALUE



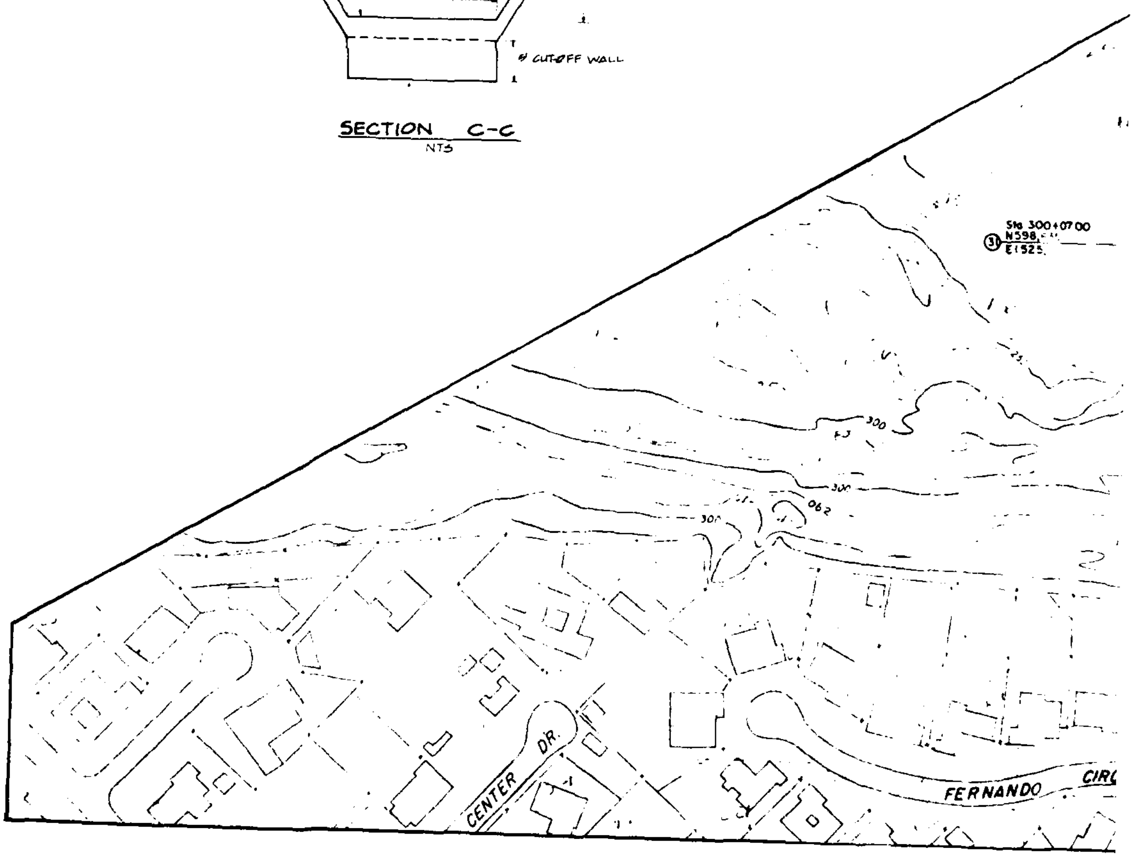
SECTION A-A
NTS



SECTION B-B
NTS



SECTION C-C
NTS

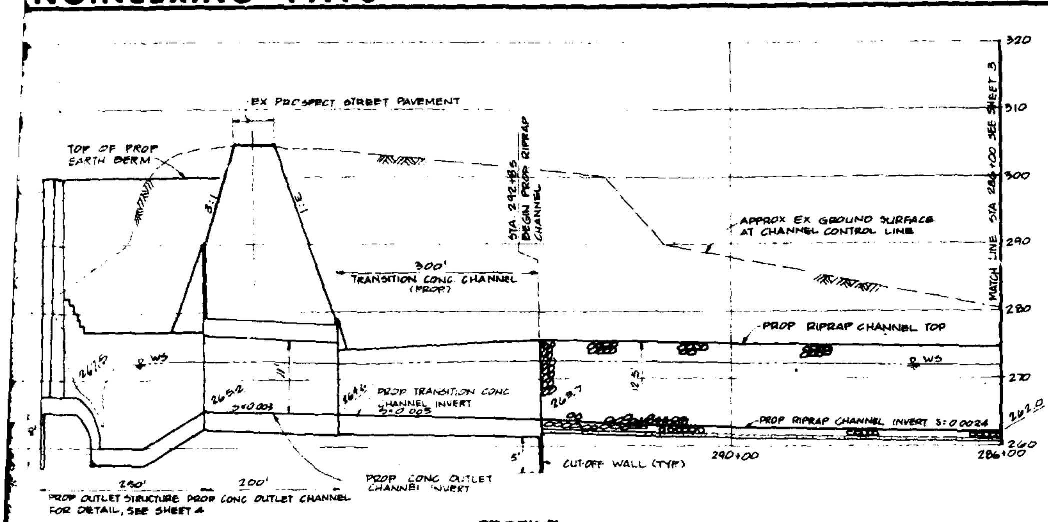


HYDRAULIC ELEMENTS								
STATION	SLOPE	Bottom Width	Q	Dc	n=0.012		n=0.016	
		ft	cfs	ft	D ft	Vel fps	D ft	Vel fps
297+90	.0003	47	3500	27	81	49	83	9.2
295+90	.0003	47	3500	57	86	86	87	88

PLAN

SA

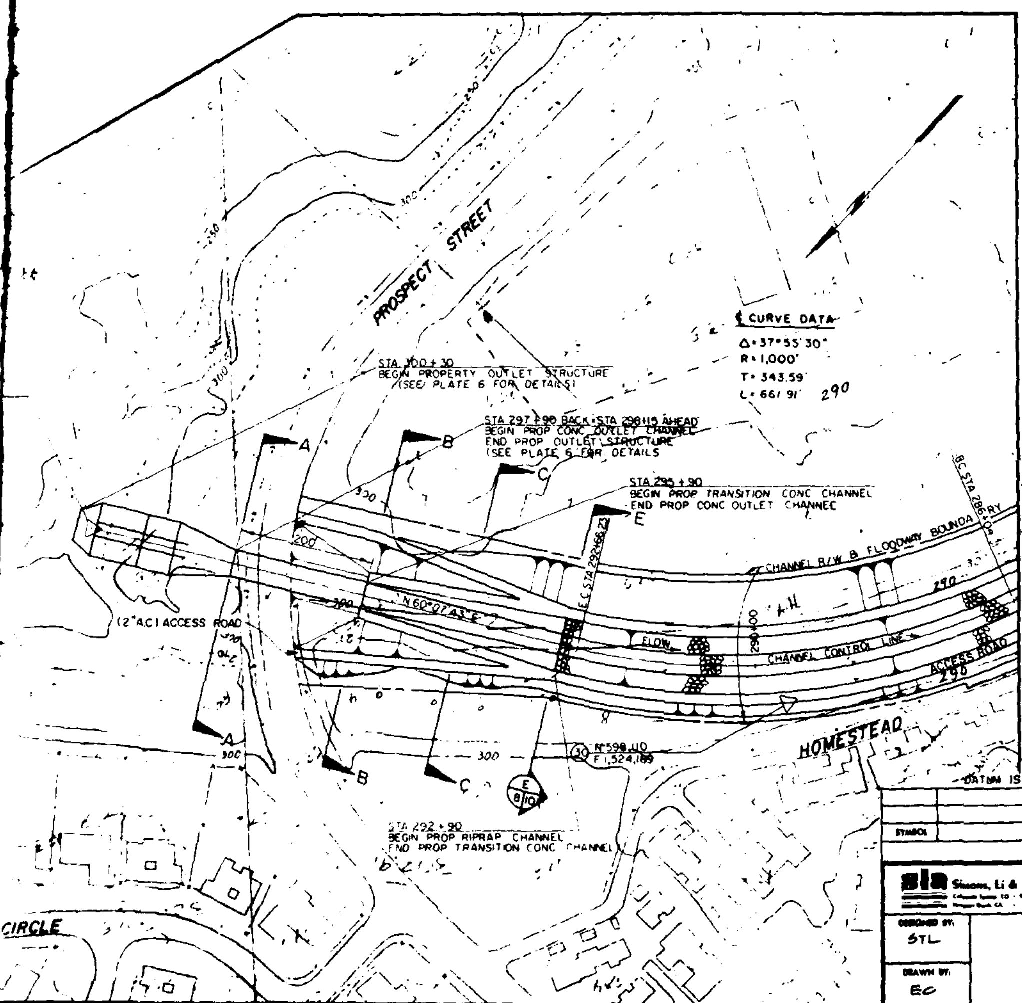
ENGINEERING PAYS



PROFILE

HORIZ SCALE 100 0 100 200 300 FEET

VERT SCALE 10 0 10 20 30 FEET



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

HYDRAULIC ELEMENTS								
STATION	SLOPE	BOTTOM WIDTH	Q	Dc	n=0.029		n=0.030	
		ft	cfs	ft	D ft	Vel fps	D ft	Vel fps
292+90	0.0024	30	3700	6.6	9.1	8.3	9.8	8.2
286+00	0.0024	30	3700	5.6	9.4	8.0	9.9	8.10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

Simons, Li & Associates, Inc.

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: STL

DRAWN BY: EC

CHECKED BY: WSL

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

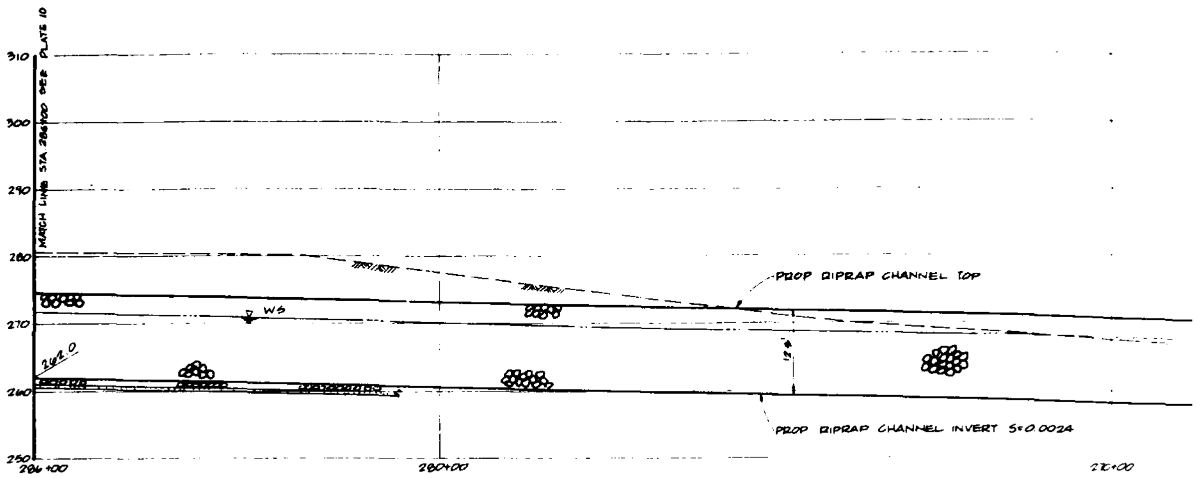
SANTIAGO CREEK CHANNEL
PLAN AND PROFILE
STA 292+85 TO STA 286+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____-B-____ | DISTRICT FILE NO. | SHEET 1 OF 2 SHEETS

PLATE

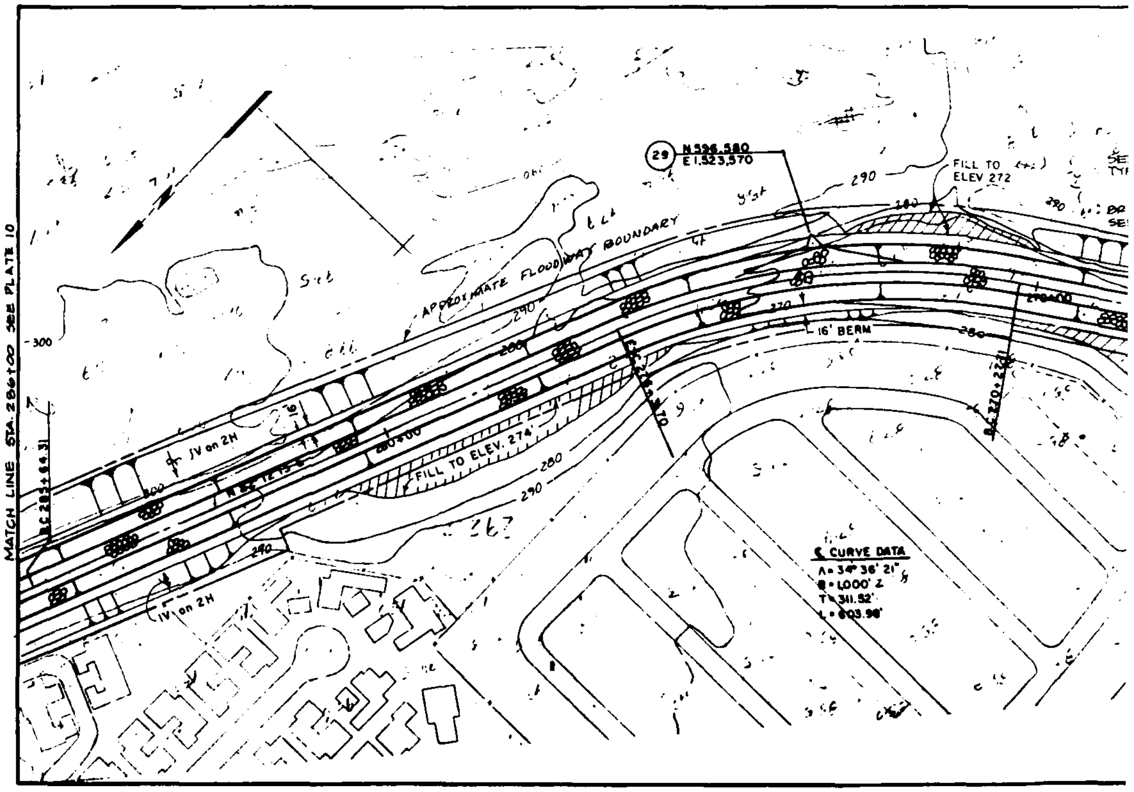
SAFETY PAYS

VALUE E



HYDRAULIC ELEMENTS

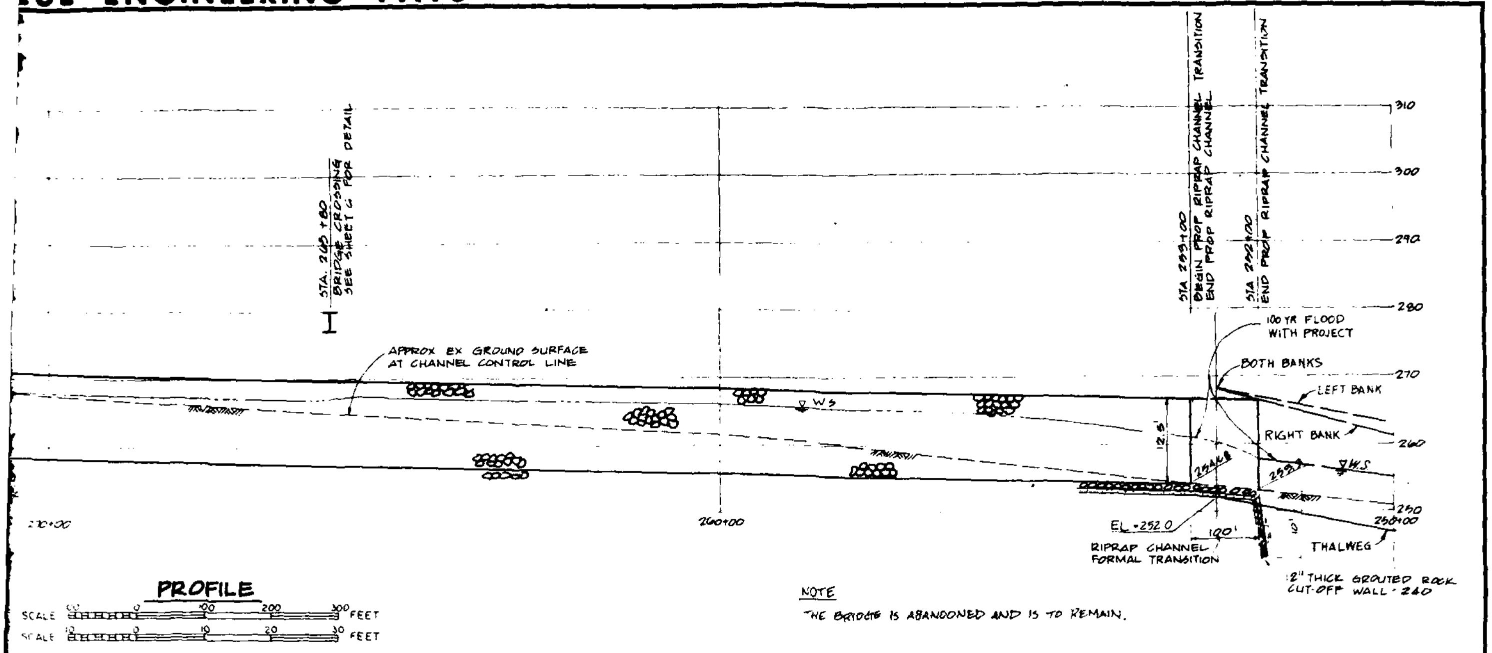
	STATION	SLOPE	BOTTOM WIDTH ft.	Q cfs.	Dc ft.	n=0.029 D ft.	n=0.029 V fps	n=0.030 D ft	n=0.030 V fps
	286+00	0.0024	30	3700	6.7	9.1	8.4	9.3	8.2
	277+85	"	"	"	"	9.2	8.3	9.4	8.1
	272+10	"	"	"	"	9.4	8.0	9.5	7.2
	266+62	"	"	"	"	9.3	8.2	9.3	8.2
	265+88	"	"	"	"	9.7	7.3	9.7	7.3
	265+33	"	"	"	"	9.5	8.0	9.5	8.0
	265+00	"	"	3900	6.9	9.3	8.6	9.3	8.6
	261+00	"	"	"	"	9.2	8.7	9.2	8.7
	257+00	"	"	"	"	8.9	9.1	8.9	9.1
	256+00	"	"	"	"	8.6	9.6	8.6	9.6
	254+00	"	"	"	"	8.4	10.0	8.4	10.0
	253+00	"	"	"	"	6.8	13.0	6.8	13.0
	252+00	"	"	"	"	4.5	9.2	4.5	9.2
	249+53	(SEE	PLATE		8)				



PLAN

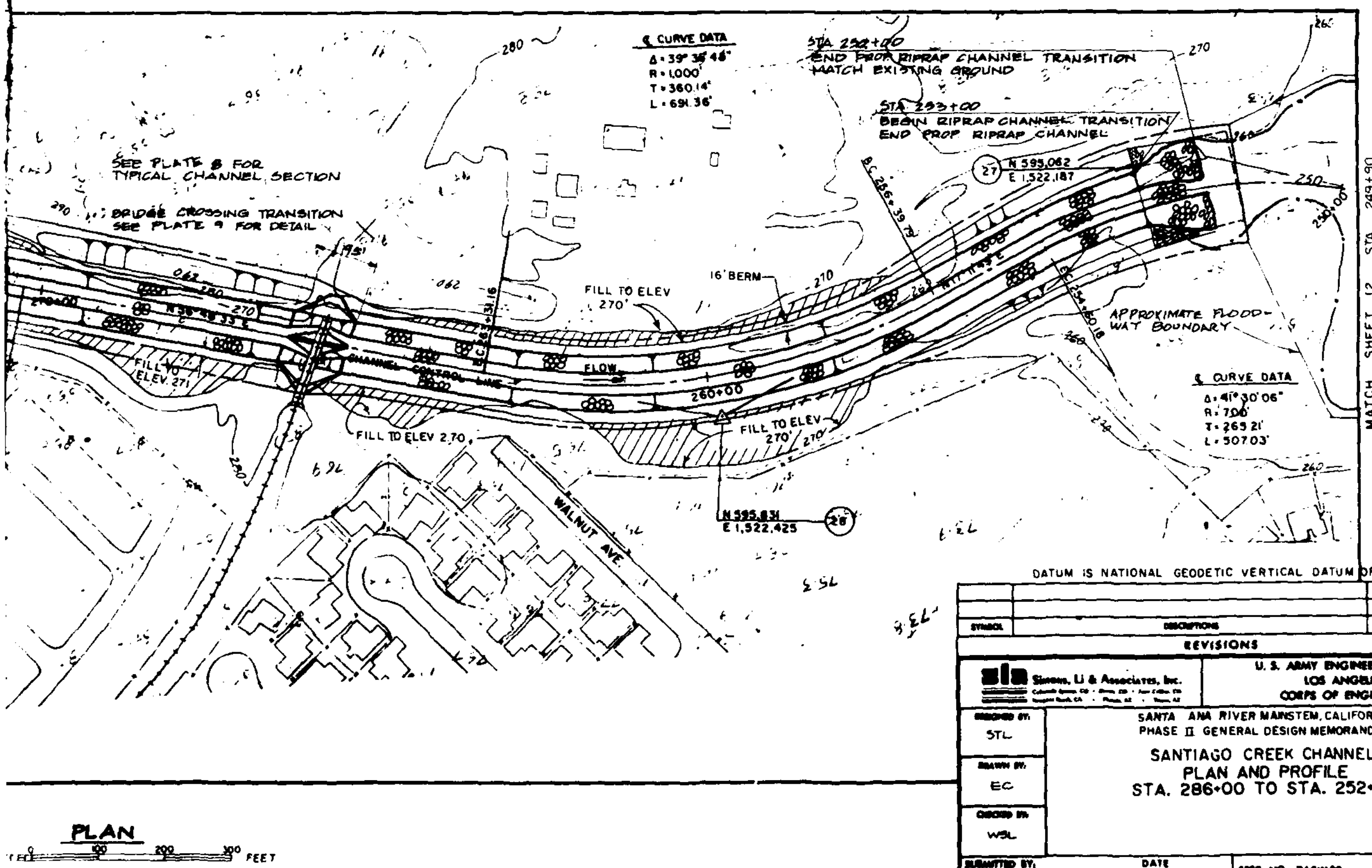
SCALE

SA



NOTE

THE BRIDGE IS ABANDONED AND IS TO REMAIN.



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

Simons, Li & Associates, Inc.

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

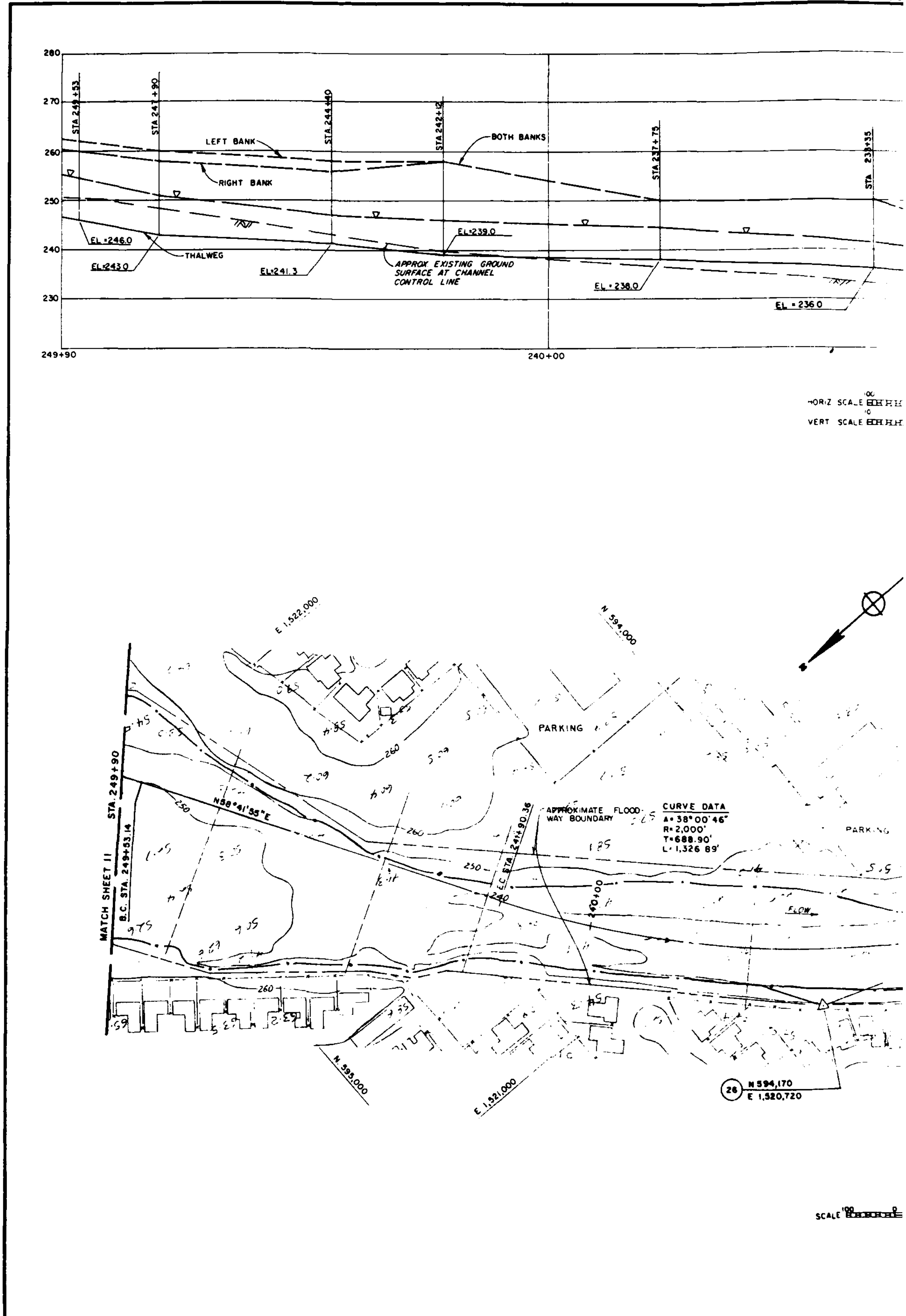
DESIGNED BY: STL
DRAWN BY: EC
CHECKED BY: WSL

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

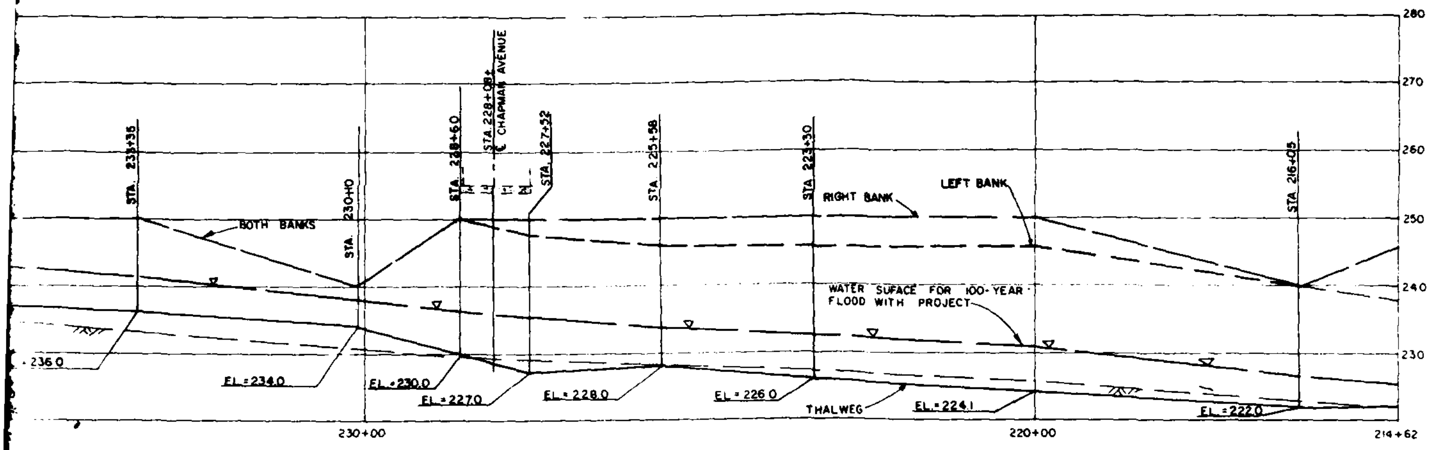
SANTIAGO CREEK CHANNEL
PLAN AND PROFILE
STA. 286+00 TO STA. 252+00

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____ B-____
DISTRICT FILE NO.
SHEET

PLATE 11


STA 249+53
STA 247+90
STA 244+40
STA 242+12
STA 237+75
STA 233+35
LEFT BANK
BOTH BANKS
RIGHT BANK
THALWEG
EL = 246.0
EL=243.0
EL=241.3
EL=239.0
APPROX EXISTING GROUND SURFACE AT CHANNEL CONTROL LINE
EL = 238.0
EL = 236.0
249+90
240+00
HORIZ SCALE
VERT SCALE
MATCH SHEET 11
STA. 249+90
B.C. STA. 249+53.14
N58°41'55"E
E.C. STA. 241+90.36
240+00
APPROXIMATE FLOOD-WAY BOUNDARY
CURVE DATA
Δ= 38°00'46"
R=2,000'
T=688.90'
L=1,326.89'
PARKING
FLOW
E 1,522,000
N 594,000
N 595,000
E 1,521,000
26
N 594,170
E 1,520,720
SCALE

SA

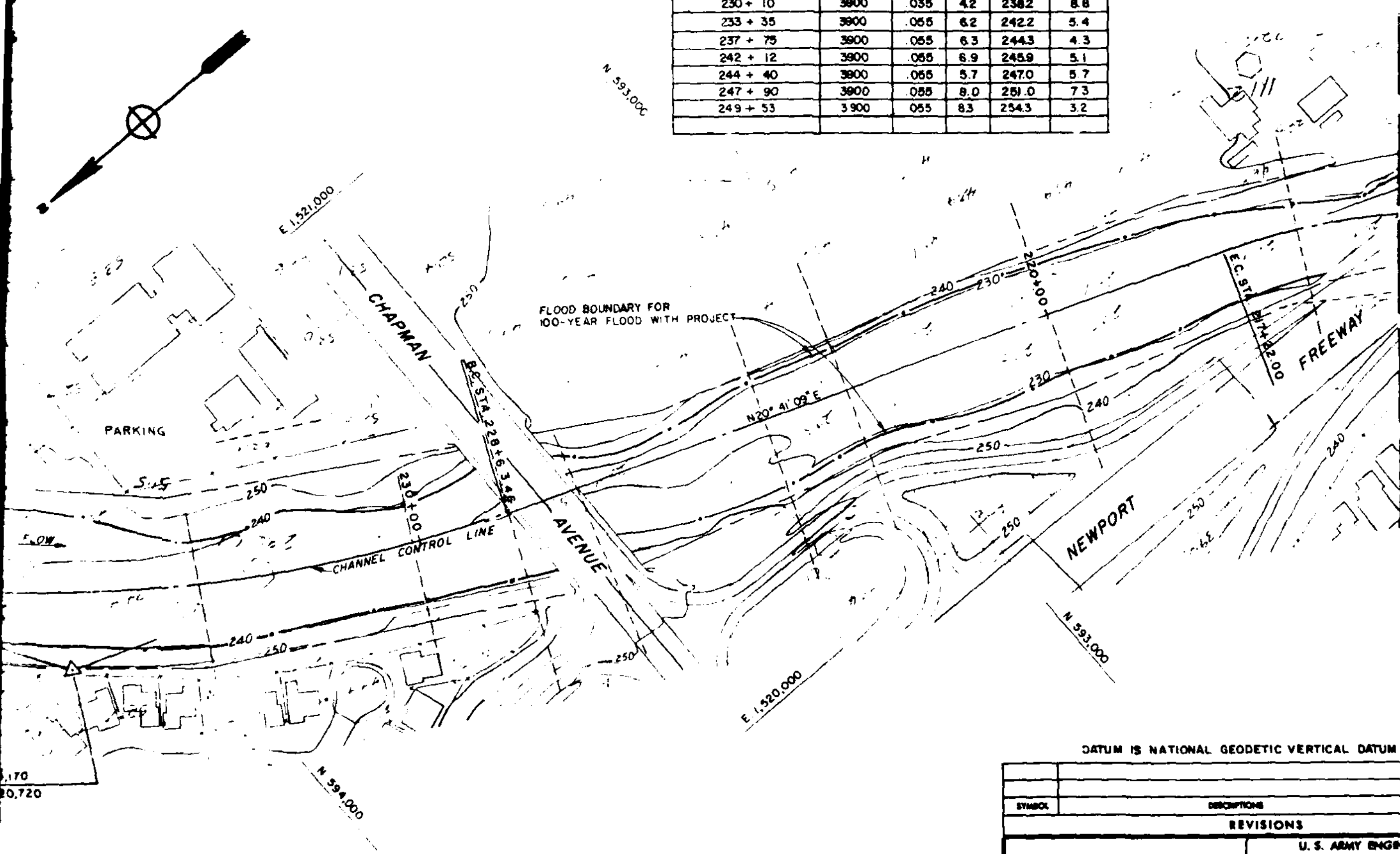


PROFILE

HORIZ SCALE 100 0 100 200 300 FEET

VERT SCALE 10 0 10 20 30 FEET

HYDRAULIC ELEMENTS					
STATION	100 YEAR DISCHARGE C.F.S.	N_{CH}	D_{MAX} FT.	W.S.EL. FT.	V_{CH} F.P.S.
216 + 05	4200	.045	4.9	226.9	10.4
220 + 00	4200	.045	6.9	231.0	5.7
223 + 30	4200	.045	6.4	232.4	6.1
225 + 58	4200	.045	5.8	233.8	6.0
227 + 52	4200	.045	8.4	235.4	7.2
228 + 60	3900	.045	6.3	236.3	6.3
230 + 10	3900	.035	4.2	238.2	8.8
233 + 35	3900	.055	6.2	242.2	5.4
237 + 75	3900	.055	6.3	244.3	4.3
242 + 12	3900	.055	6.9	245.9	5.1
244 + 40	3900	.055	5.7	247.0	5.7
247 + 90	3900	.055	8.0	251.0	7.3
249 + 53	3900	.055	8.3	254.3	3.2



PLAN

SCALE 100 0 100 200 300 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: F CASTELLANOS

CHECKED BY:

SANTIAGO CREEK CHANNEL
EXISTING PLAN AND PROFILE
STA.252+00 TO STA.214+62

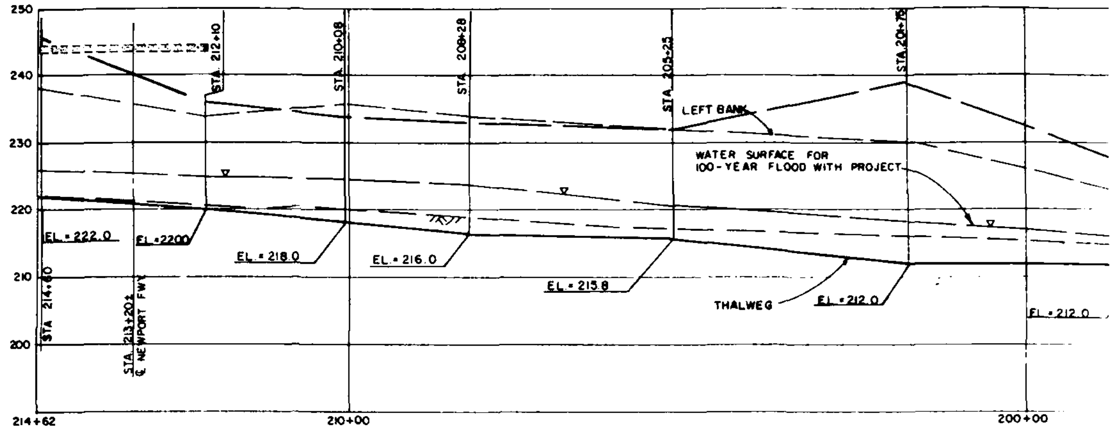
SUBMITTED BY:

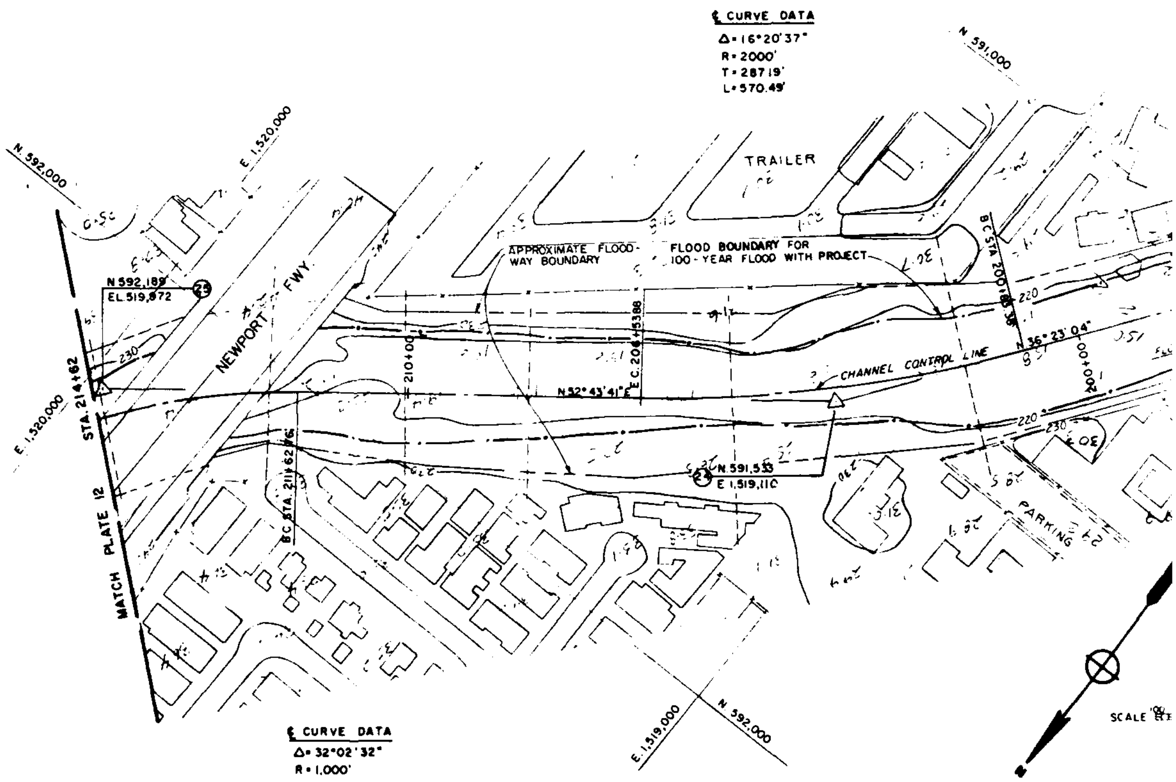
DATE APPROVED:

SPEC. NO. DACW09-

DISTRICT FILE NO.

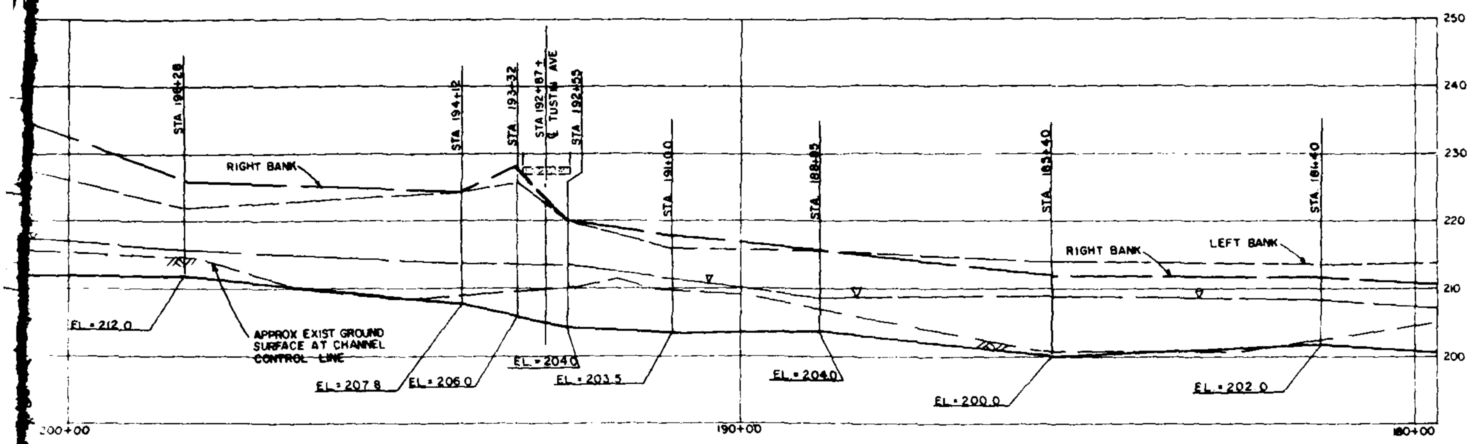
SHEET 1 OF 5 SHEETS





HYDRAULIC ELEMENTS					
STATION	100 YEAR DISCHARGE C.F.S.	N_{CH}	D_{MAX} FT.	W.S.EL. FT	V_{CH} F.P.S.
181 + 40	4350	.035	6.7	206.7	3.2
185 + 40	4350	.035	9.0	209.0	2.3
188 + 85	4350	.035	4.8	208.8	8.0
191 + 00	4350	.035	8.2	211.7	8.8
192 + 55	4350	.035	9.3	213.3	5.4
193 + 32	4200	.035	7.5	213.5	4.4
194 + 12	4200	.035	5.8	213.6	6.6
198 + 28	4200	.035	3.5	215.5	8.4
201 + 75	4200	.035	5.9	217.9	6.6
205 + 25	4200	.035	4.6	220.6	11.0
208 + 28	4200	.035	7.6	223.7	6.3
210 + 03	4200	.035	6.2	224.2	6.0
212 + 10	4200	.035	4.8	224.8	6.6
214 + 10	4200	.035	3.4	225.4	8.9

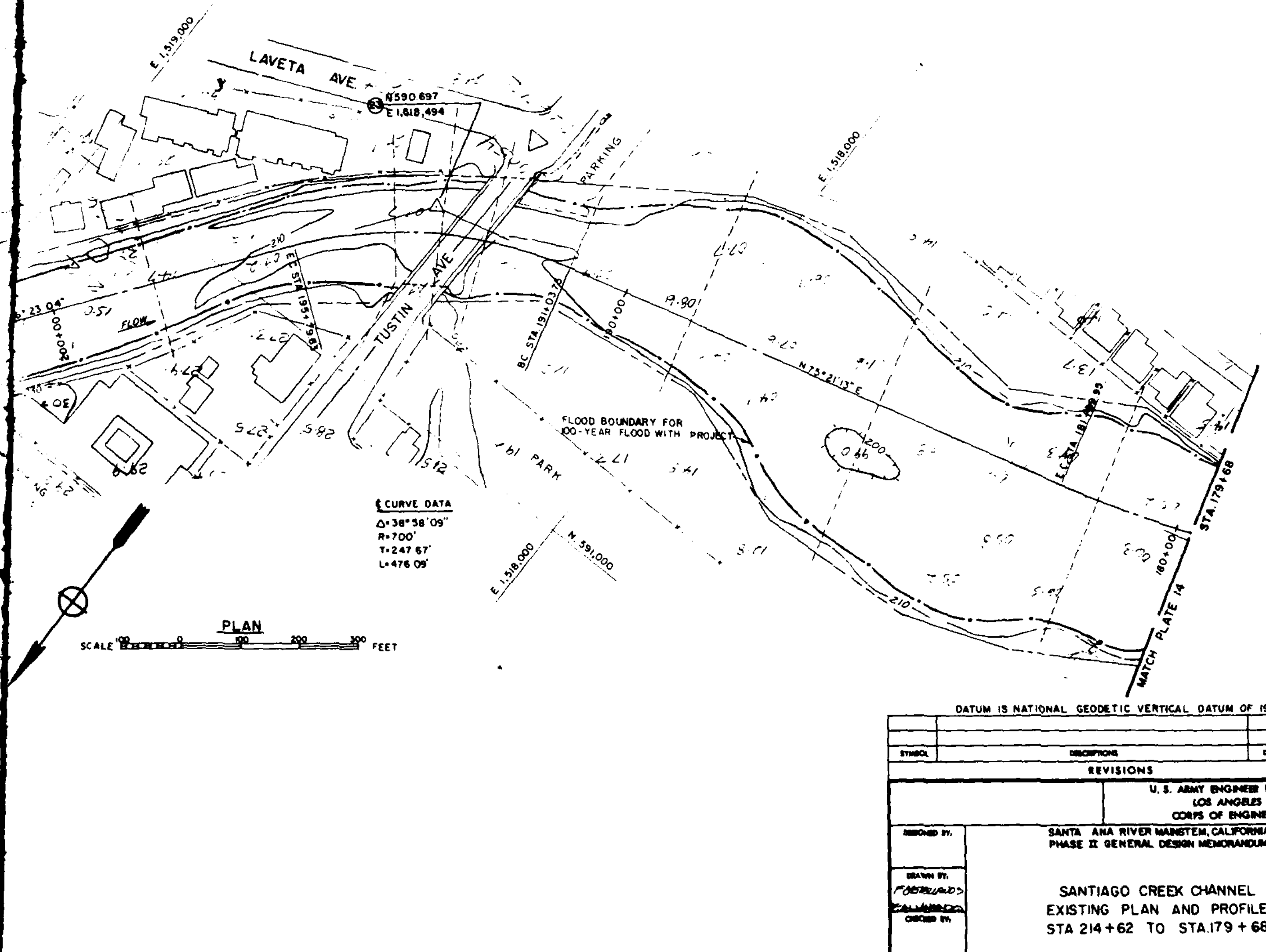
ALUE ENGINEERING PAYS



PROFILE

HORIZ SCALE 100 0 100 200 300 FEET

VERT SCALE 10 0 10 20 30 FEET



℄ CURVE DATA

Δ = 38°58'09"

R = 700'

T = 247.67'

L = 476.09'

PLAN

SCALE 100 0 100 200 300 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL
EXISTING PLAN AND PROFILE
STA 214+62 TO STA.179+68

SUBMITTED BY:

DATE APPROVED:

SPEC. NO. DACW09-____ B-____

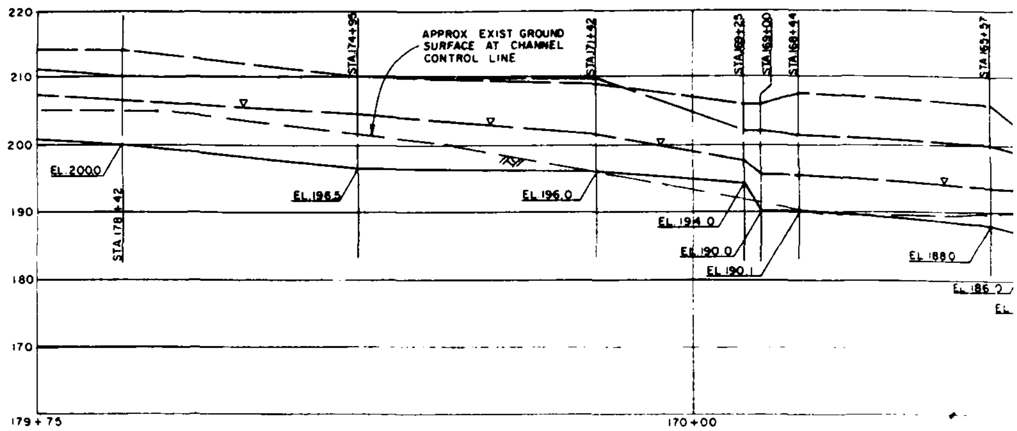
DISTRICT FILE NO.

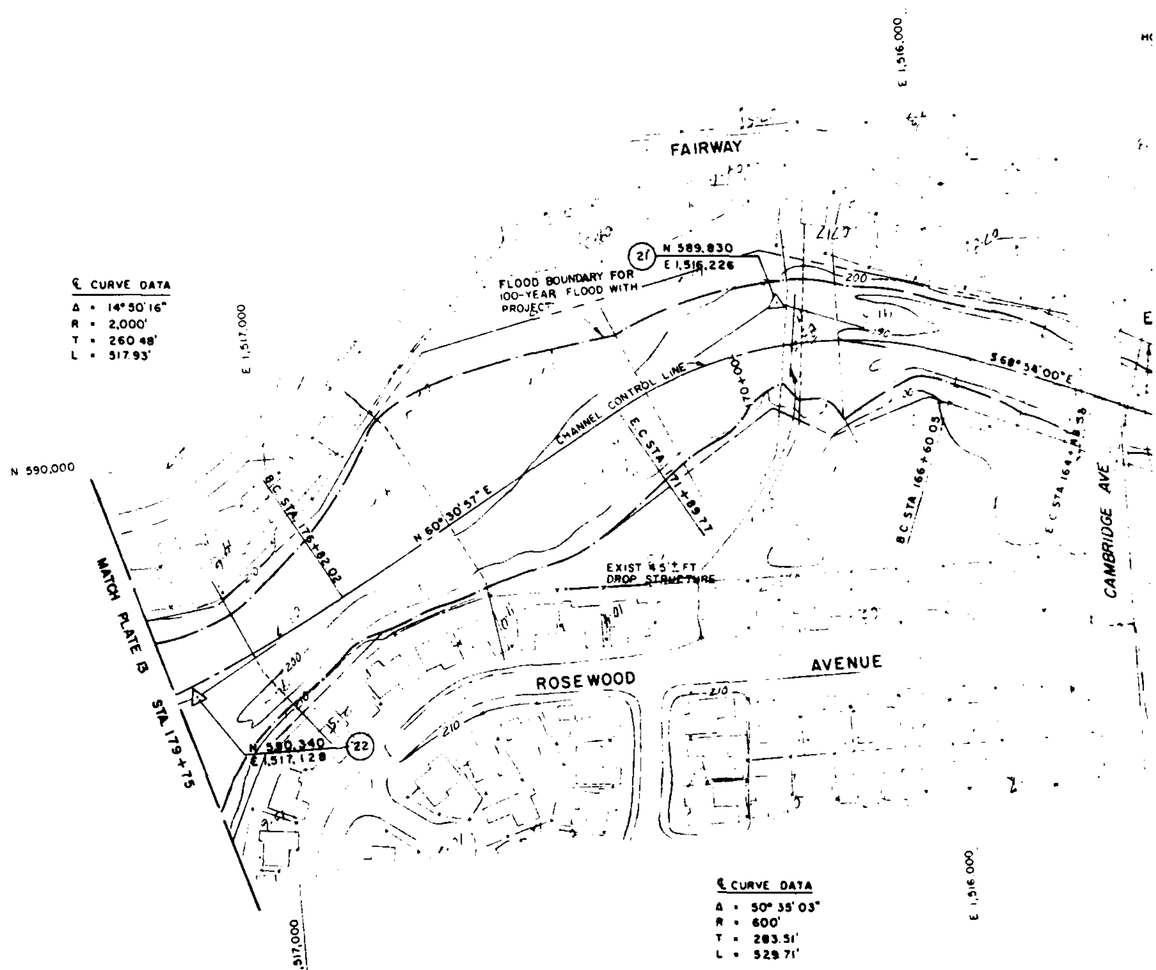
SHEET 2 OF 5 SHEETS

SAFETY PAYS

PLATE 13

VALUE





℄ CURVE DATA

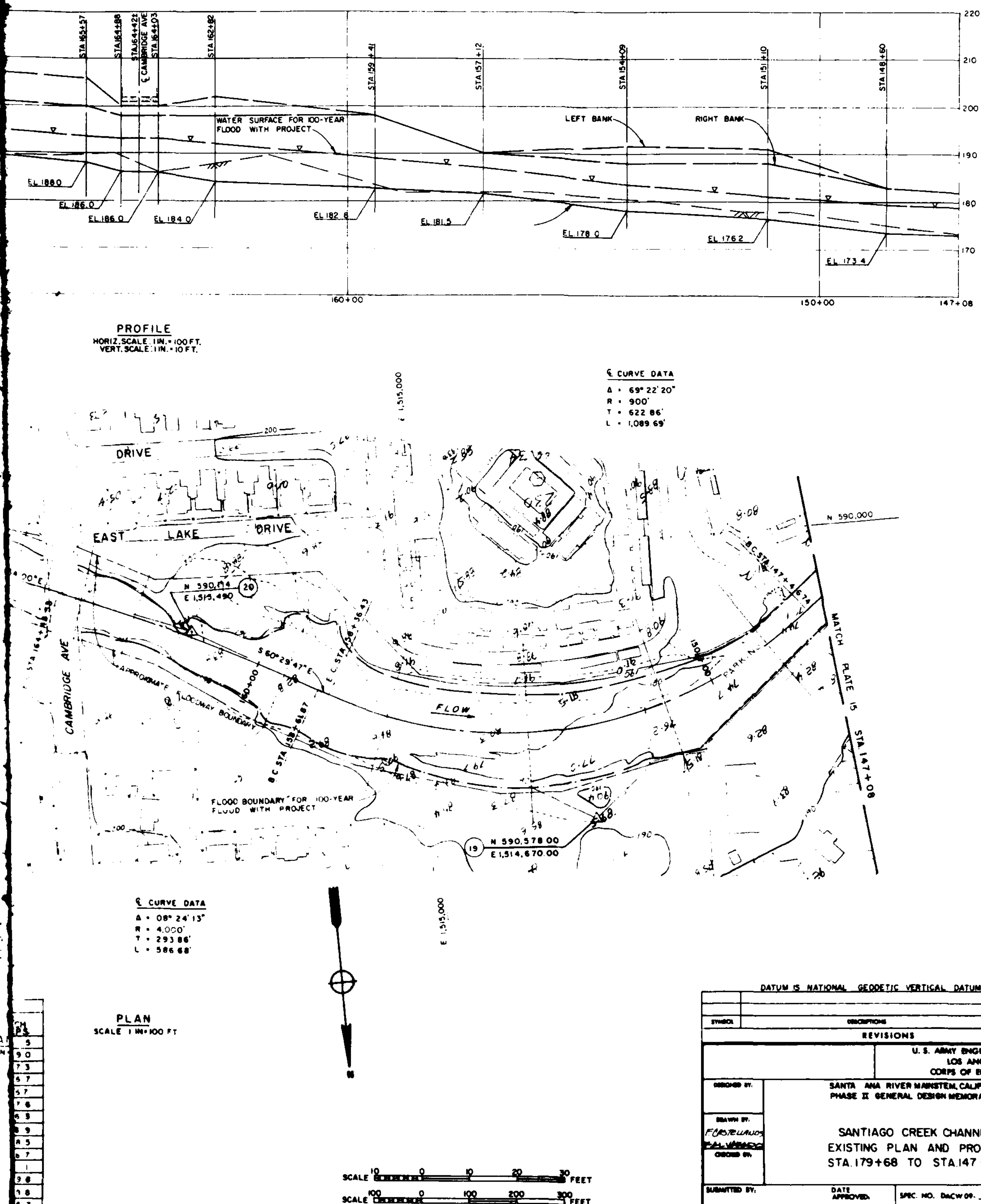
Δ = 50° 35' 03"
R = 600'
T = 283.51'
L = 529.71'

E 1,516,000

E 1,517,000

HYDRAULIC ELEMENTS					
STATION	100 YEAR DISCHARGE C.F.S.	N_{CH}	D_{MAX} FT.	W.S. EL. FT.	V_{CH} F.P.S.
148 + 60	4500	.018	6.2	179.6	11.5
151 + 10	4500	.018	5.1	181.3	9.0
154 + 09	4500	.050	5.3	183.3	7.3
157 + 12	4500	.050	8.0	186.5	6.7
159 + 41	4500	.050	6.0	188.9	6.7
162 + 82	4500	.050	7.8	191.8	7.6
164 + 03	4500	.050	6.8	192.8	6.3
164 + 88	4350	.050	6.9	192.9	6.9
165 + 37	4350	.035	5.1	193.1	8.5
168 + 44	4350	.035	5.1	195.2	6.7
169 + 00	4350	.035	5.7	195.7	5.1
169 + 25	4350	.035	3.7	197.7	9.8
171 + 42	4350	.035	5.2	201.2	8.8
174 + 95	4350	.035	8.2	204.7	5.7
178 + 42	4350	.035	6.7	208.7	9.5

S



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: F. CASTELLANOS

F. ALVARADO

CHECKED BY:

SANTIAGO CREEK CHANNEL
EXISTING PLAN AND PROFILE
STA. 179+68 TO STA. 147+08

SUBMITTED BY:

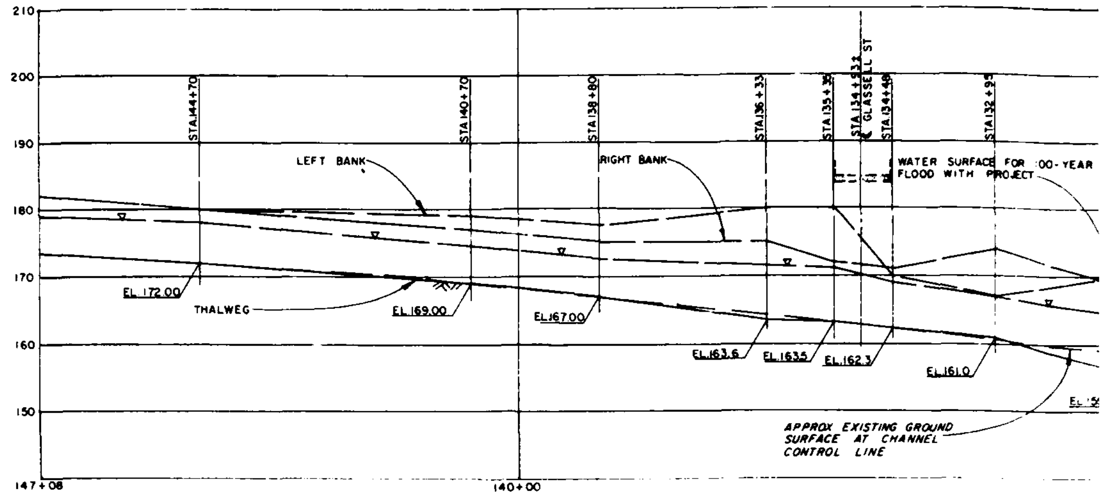
DATE APPROVED:

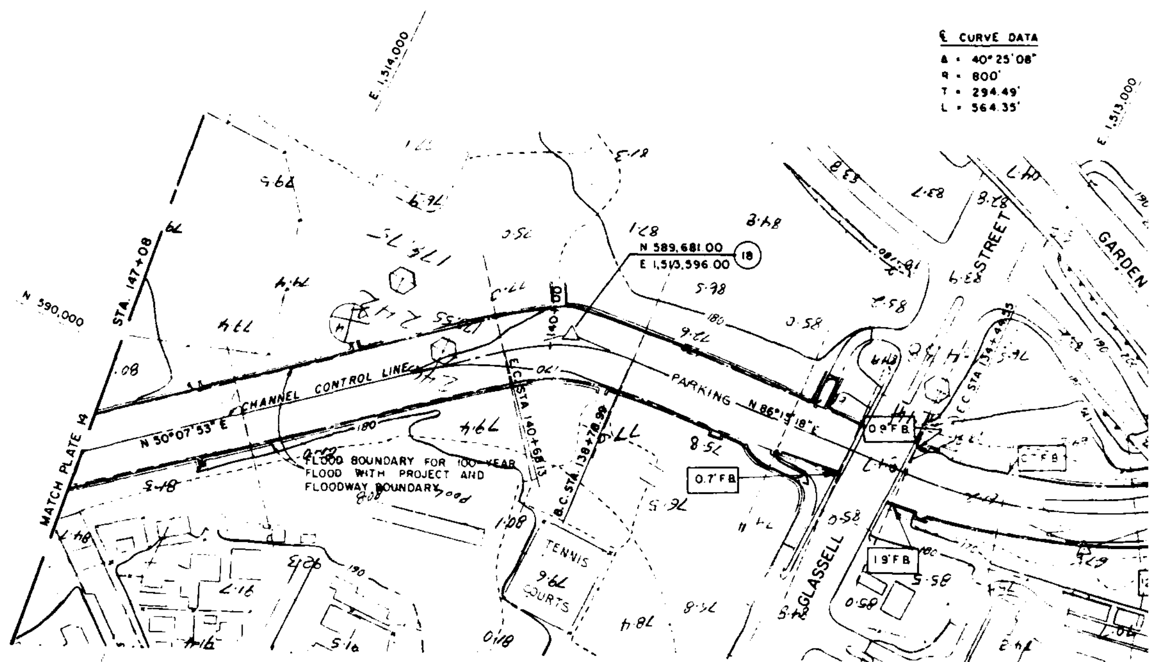
SPEC. NO. DACW09-____-B-____

DISTRICT FILE NO.

SHEET 3 OF 5 SHEETS

PLATE 14



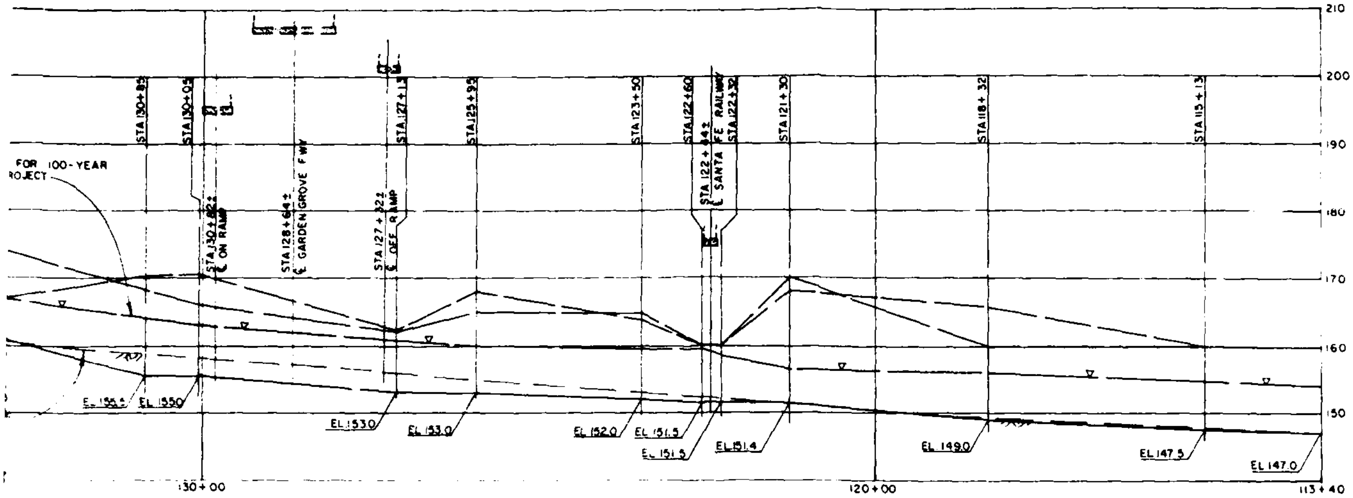


HYDRAULIC ELEMENTS					
STATION	100 YEAR DISCHARGE C.F.S.	N_{CH}	D_{MAX} FT.	W.S.EL. FT.	V_{CH} F.P.S.
113 + 40	4700	.030	6.8	153.8	9.4
115 + 13	4700	.030	7.3	154.8	8.3
118 + 32	4700	.030	6.9	155.9	9.7
121 + 30	4700	.030	5.3	156.7	11.3
122 + 32	4700	.030	7.0	158.5	8.1
122 + 60	4700	.030	8.2	159.7	6.5
123 + 50	4700	.030	7.7	159.7	7.8
125 + 95	4700	.030	6.9	159.9	9.6
127 + 13	4700	.030	7.4	160.4	9.8
130 + 05	4500	.035	8.3	163.3	9.1
130 + 85	4500	.035	8.2	163.7	8.9
132 + 95	4500	.035	5.6	166.6	11.2
134 + 48	4500	.035	6.6	168.9	8.2
135 + 35	4500	.018	7.5	171.0	8.2
136 + 33	4500	.018	7.5	171.1	8.2
138 + 80	4500	.018	5.8	172.8	11.4
140 + 70	4500	.018	5.5	174.5	11.1
144 + 70	4500	.018	5.7	177.7	11.4

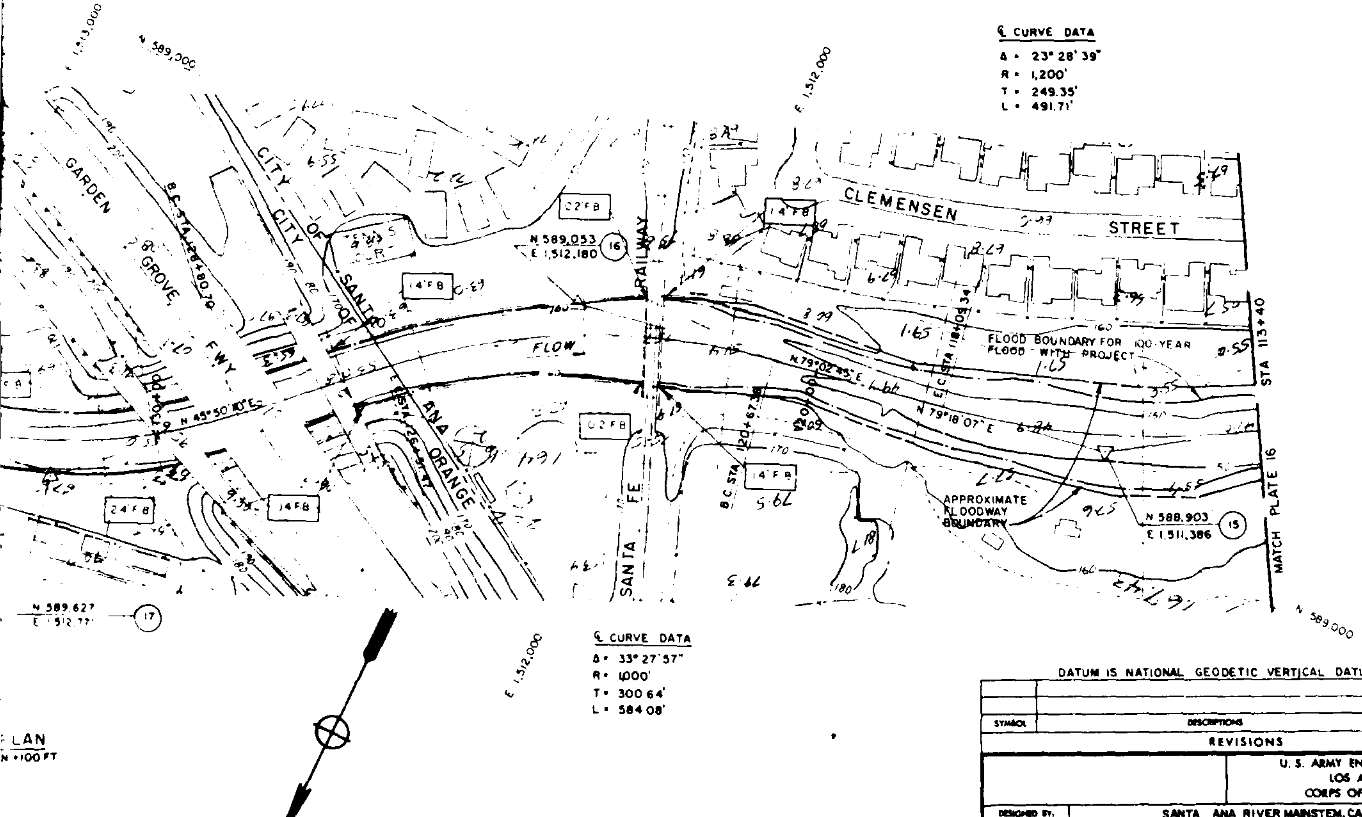
℄ CURVE DATA
Δ = 36°07'25"
R = 300'
T = 97.83'
L = 189.14'

PLAN
1 IN = 100 FT

S



PROFILE
HORIZ. SCALE: 1 IN. = 100 FT.
VERT. SCALE: 1 IN. = 10 FT.



PLAN
1 IN. = 100 FT

SCALE 10 0 10 20 30 FEET

SCALE 100 0 100 200 300 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: F CASTELLANOS

CHECKED BY:

SANTIAGO CREEK CHANNEL
EXISTING PLAN AND PROFILE
STA 147+08 TO STA 113+40

SUBMITTED BY:

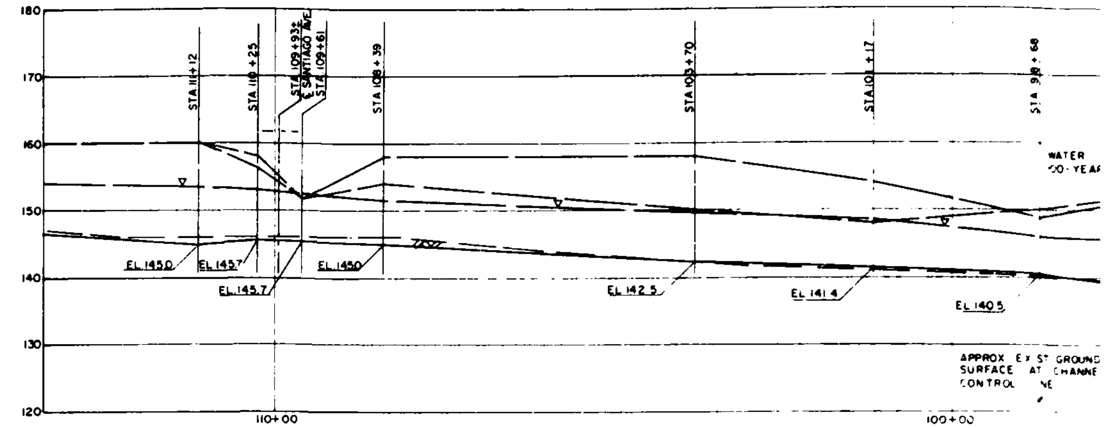
DATE APPROVED:

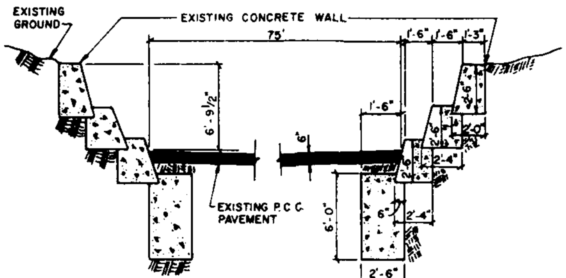
SPEC. NO. DACW09-

DISTRICT FILE NO

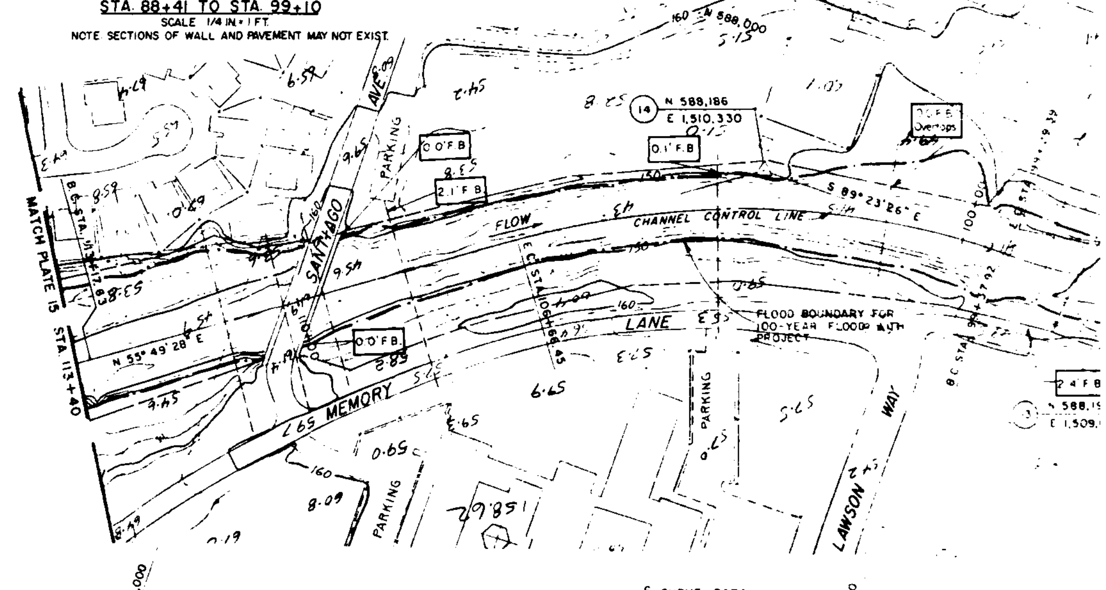
SHEET 4 OF 5 SHEETS

VALUE



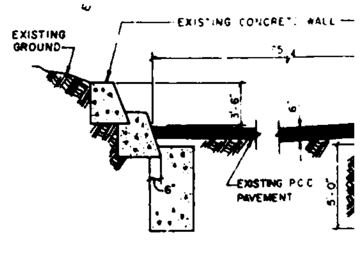


TYPICAL SECTION
CONCRETE WALL AND PAVEMENT
STA. 88+41 TO STA. 99+10
SCALE 1/4 IN. = 1 FT.
NOTE: SECTIONS OF WALL AND PAVEMENT MAY NOT EXIST.

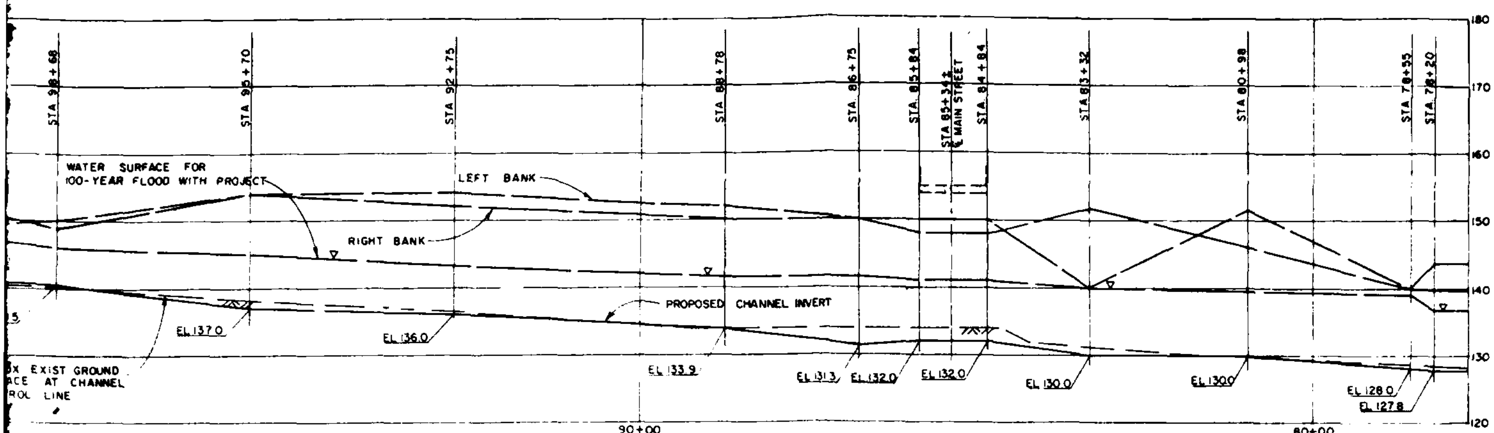


HYDRAULIC ELEMENTS					
STATION	100 YEAR DISCHARGE C.F.S.	N_{CH}	D_{MAX} FT.	W.S. EL. FT.	V_{CH} F.P.S.
78 + 20	4700	.030	8.9	136.7	8.1
78 + 55	4700	.030	11.2	139.2	6.0
80 + 98	4700	.030	9.5	139.5	6.8
83 + 32	4700	.030	9.6	139.8	7.9
84 + 80	4700	.030	8.6	140.6	5.7
85 + 85	4700	.030	8.9	140.9	5.4
86 + 75	4700	.030	9.5	140.8	7.6
88 + 78	4700	.030	7.0	140.9	10.5
92 + 75	4700	.030	7.1	143.1	11.1
95 + 70	4700	.030	8.1	145.1	8.5
98 + 68	4700	.030	6.0	146.5	11.0
101 + 17	4700	.030	7.3	148.7	8.4
103 + 70	4700	.030	7.0	149.5	9.5
108 + 39	4700	.030	6.8	151.8	8.1
109 + 61	4700	.030	6.8	152.5	6.6
110 + 25	4700	.030	7.5	153.2	7.0
111 + 12	4700	.030	8.5	153.5	6.5

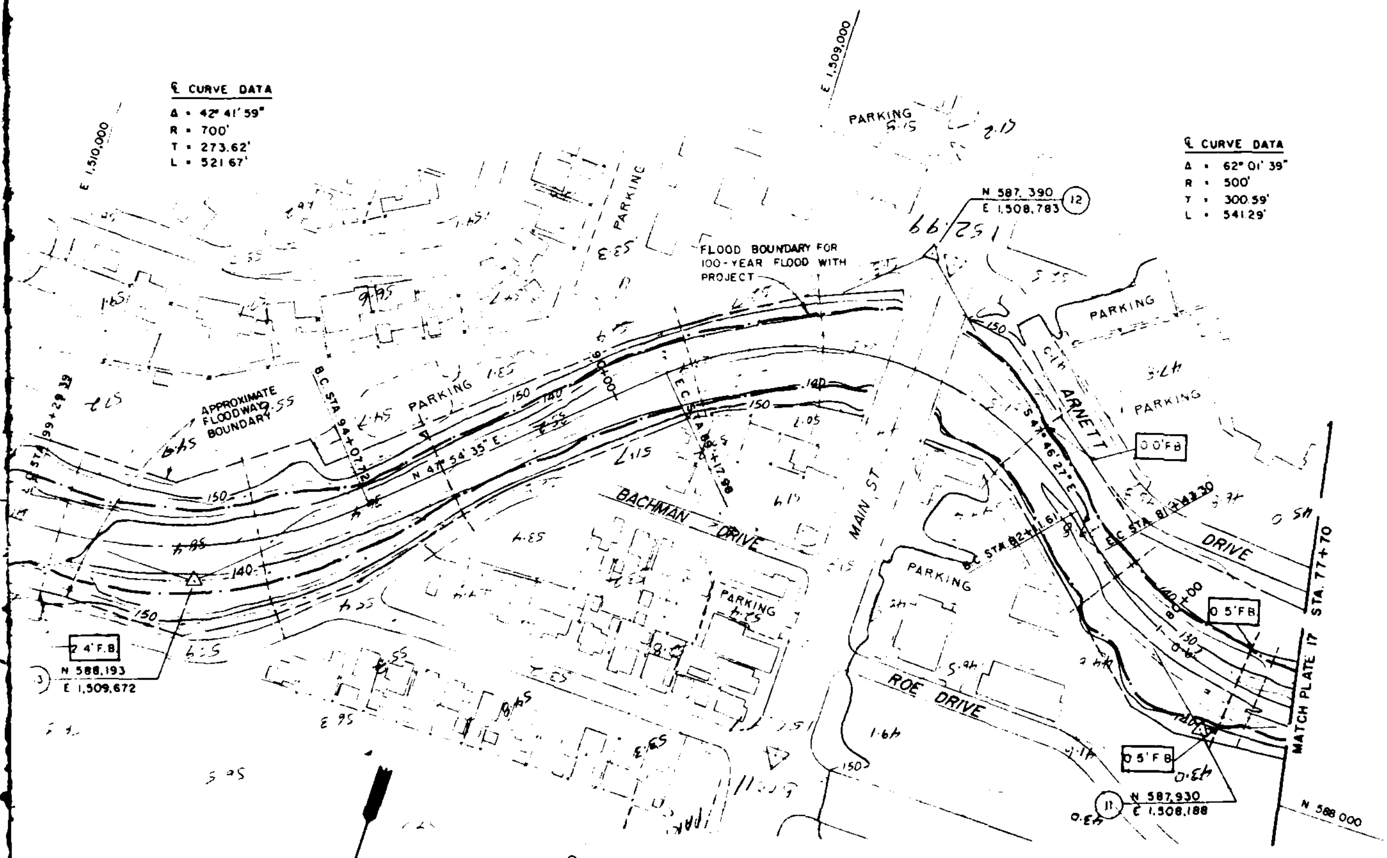
℄ CURVE DATA
Δ = 34° 47' 06"
R = 1,200'
T = 375.88'
L = 728.53'



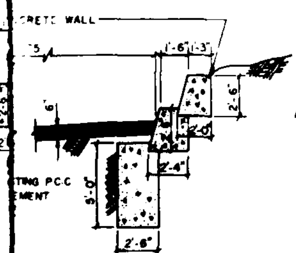
TYPICAL SECTION
CONCRETE WALL AND PAVE
STA. 99+10 TO STA 109+
SCALE 1/4 IN. = 1 FT.
NOTE: SECTIONS OF WALL AND PAVEMENT MAY



PROFILE
HORIZ. SCALE: 1 IN. = 100 FT.
VERT. SCALE: 1 IN. = 10 FT.



℄ CURVE DATA
Δ = 84° 18' 52"
R = 480'
T = 434.59'
L = 706.36'



SECTION
L AND PAVEMENT
TO STA 109+93
IN = 1 FT
PAVEMENT MAY NOT EXIST

SCALE 10 0 10 20 30 FEET
SCALE 100 0 100 200 300 FEET
SCALE 1 0 2 4 6 8 10 12 14 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

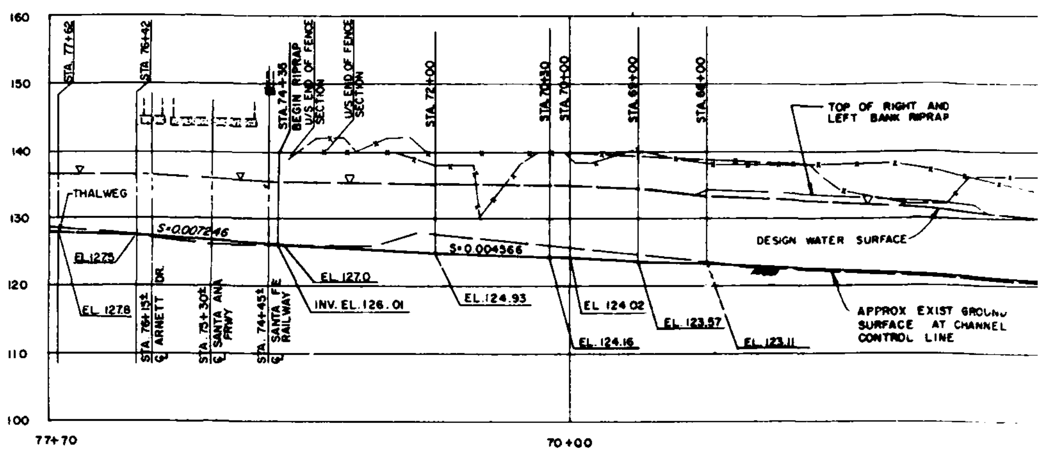
DRAWN BY: F. CASTELLANOS / F. ALVARADO
CHECKED BY:

SANTIAGO CREEK CHANNEL
EXISTING PLAN AND PROFILE
STA. 113+40 TO STA. 77+70

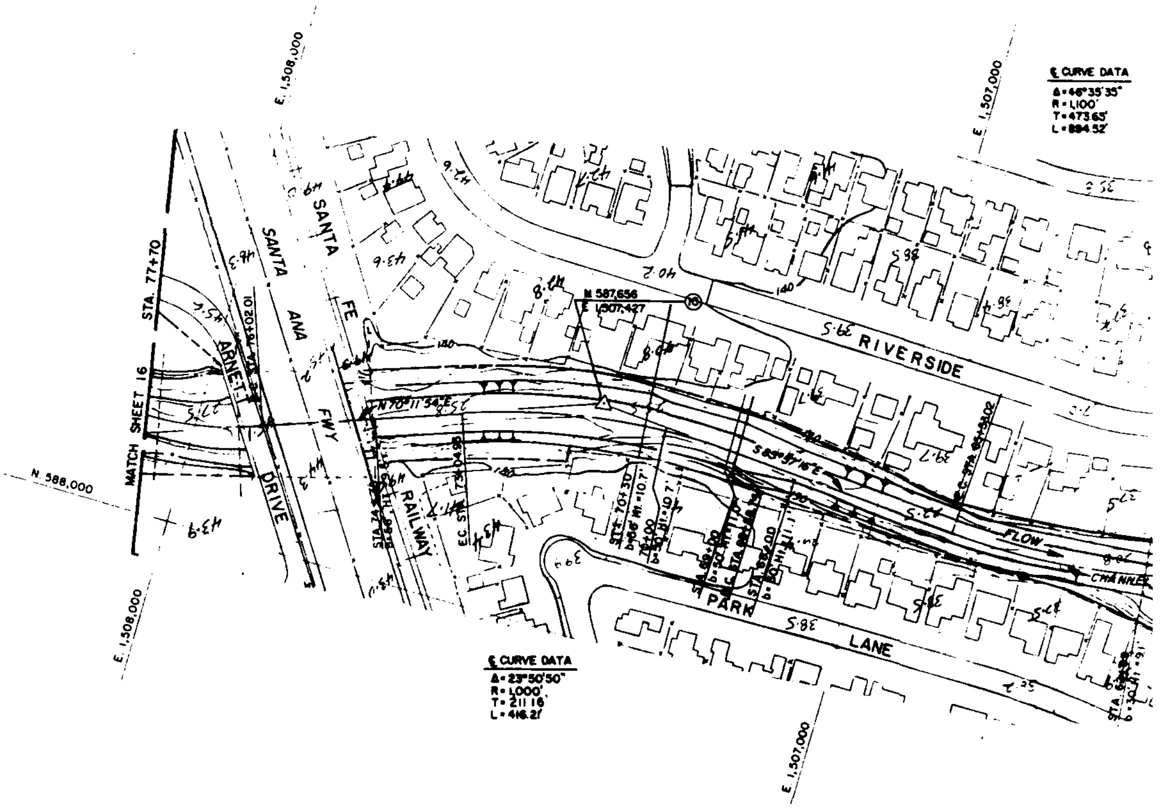
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____-B-____ | SHEET 5 OF 5 SHEETS
DISTRICT FILE NO.

PLATE 16

VALUE E



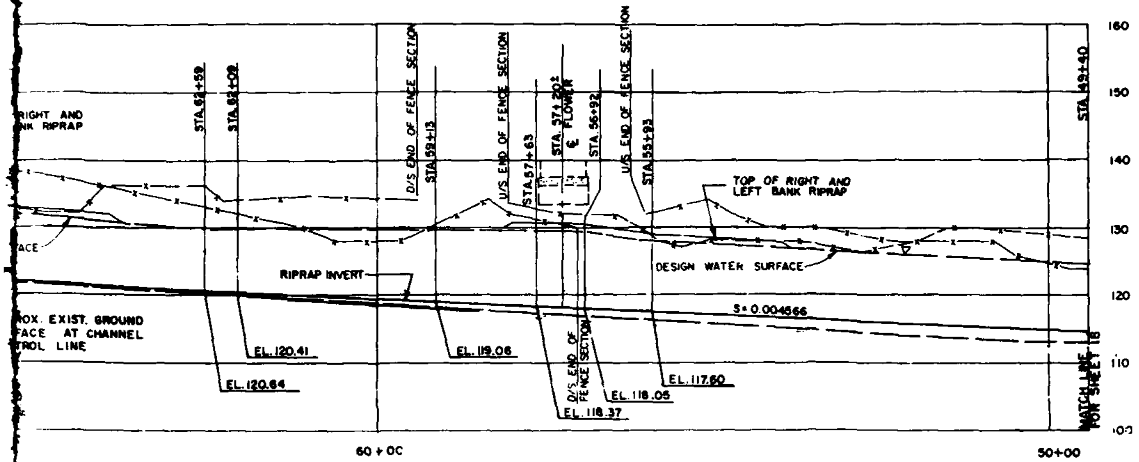
PROFILE
HORIZ. SCALE: 1 IN. =
VERT. SCALE: 1 IN. =



PLAN
SCALE 1 IN = 100 FT

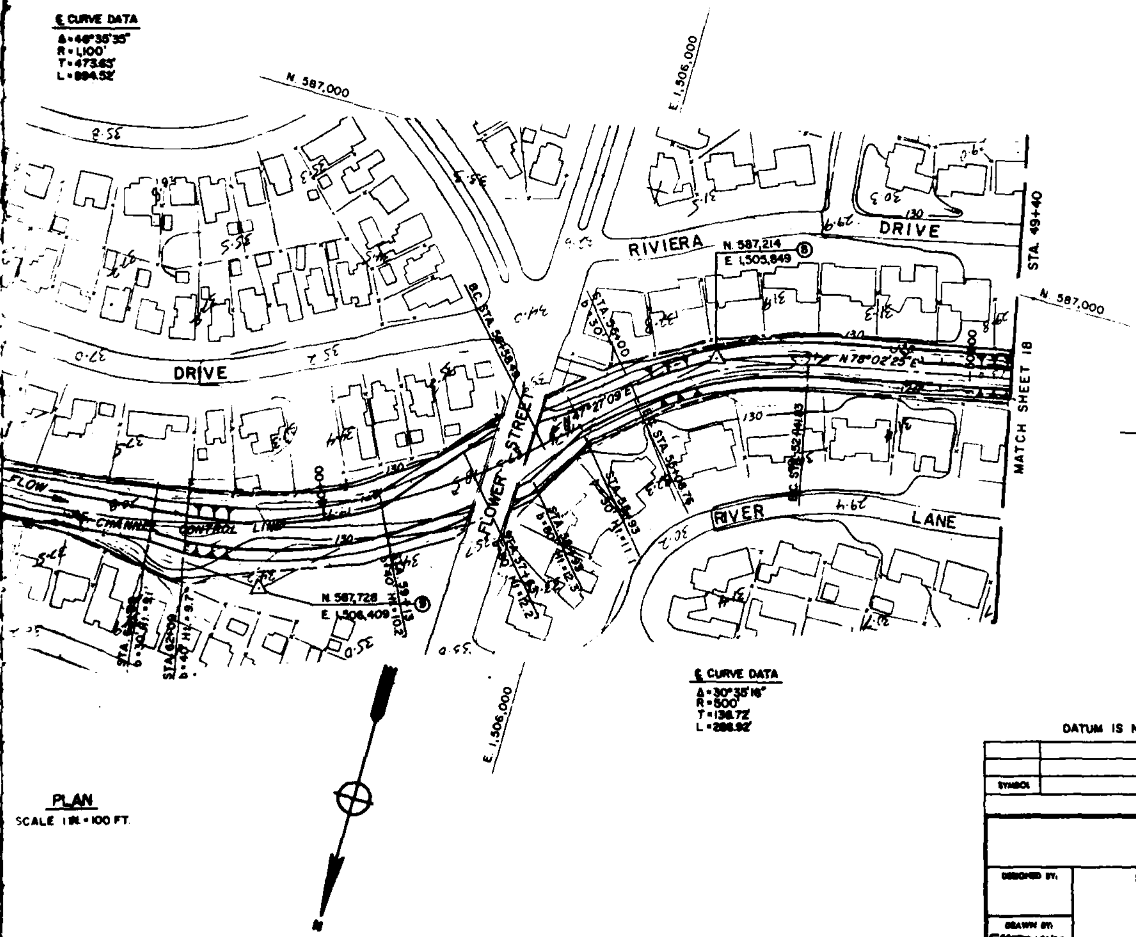
HYDRAULIC ELEMENTS					
STATION	100 YEAR DISCHARGE C.F.S.	N_{CH}	D_{MAX}	WSEL	V_{CH}
74 + 35	4700	.030	9.4	135.4	6.4
76 + 42	4700	.030	8.9	136.4	6.4
77 + 62	4700	.030	8.7	136.5	6.5

SA



PROFILE
HORIZ. SCALE: 1 IN. = 100 FT.
VERT. SCALE: 1 IN. = 10 FT.

NOTES
1. UNLESS OTHERWISE SHOWN, TOP OF RIGHT AND LEFT BANK RIPRAP IS SAME AS DESIGN WATER SURFACE
2. SYMBOL —·—x—·— DENOTES GROUND ELEVATION AT RIGHT BANK FENCE LINE
3. SYMBOL —x—x— DENOTES GROUND ELEVATION AT LEFT BANK FENCE LINE
4. HYDRAULIC ELEMENTS DOWNSTREAM OF STA. 74 + 35 ARE SHOWN ON PLATE 21



PLAN
SCALE 1 IN. = 100 FT.

LEGEND
- - - - - APPROXIMATE FLOODWAY LOCATION

SCALE 10 0 10 20 30 FEET
SCALE 100 0 100 200 300 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

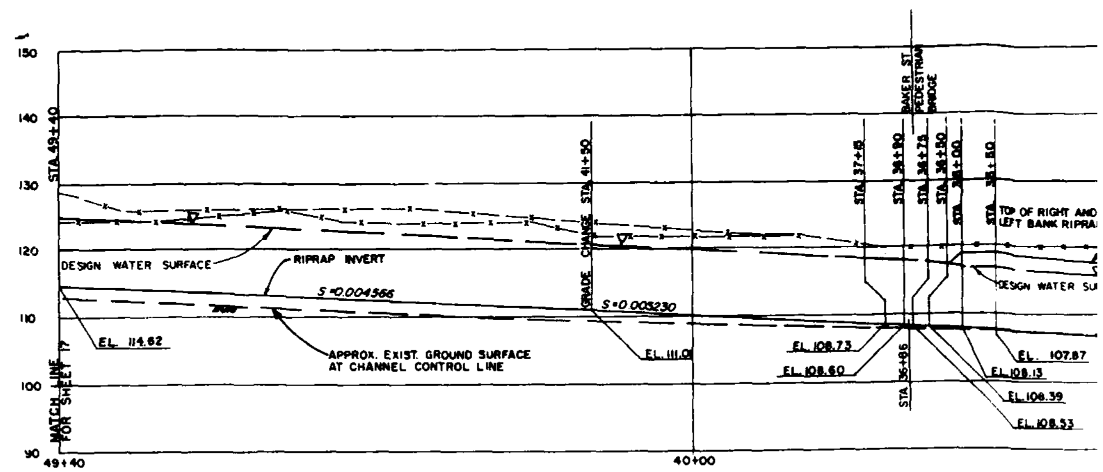
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

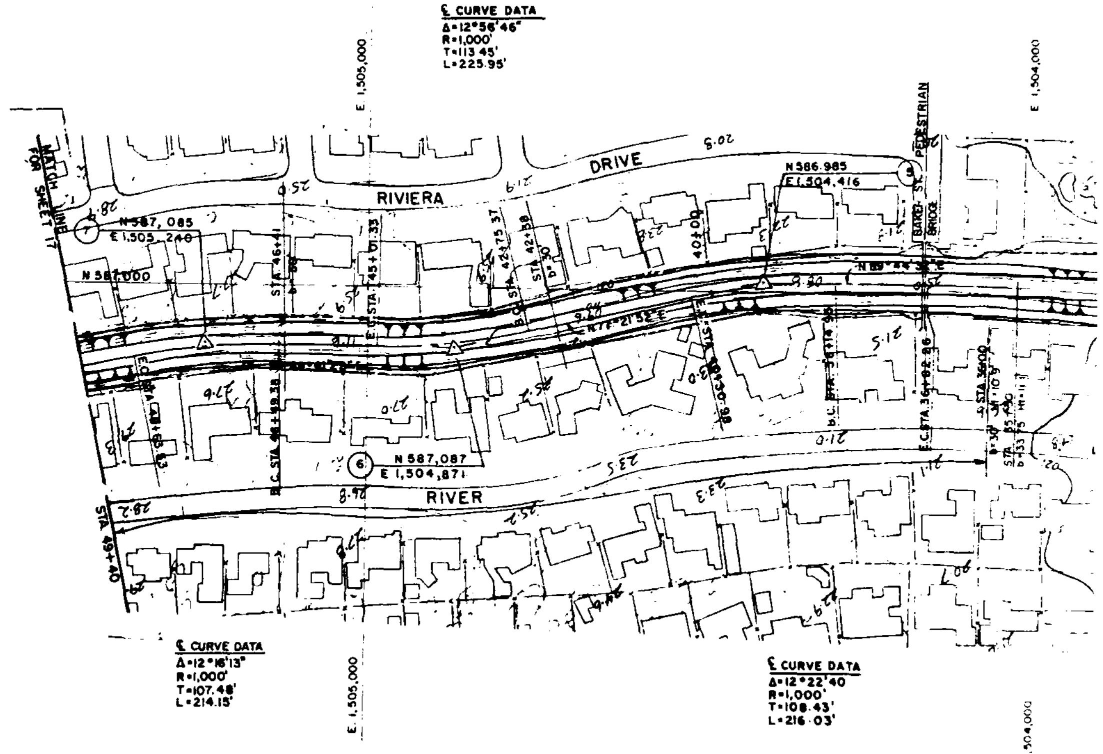
DESIGNED BY:
DRAWN BY: F. OSTROLANOS, E. ALVARADO
CHECKED BY:

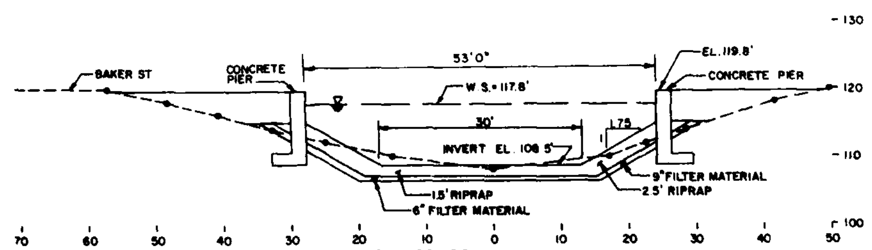
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL
PLAN AND PROFILE
STA. 77+70 TO STA. 49+40

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____ B-____
DISTRICT FILE NO.
SHEET 1 OF 3 SHEETS





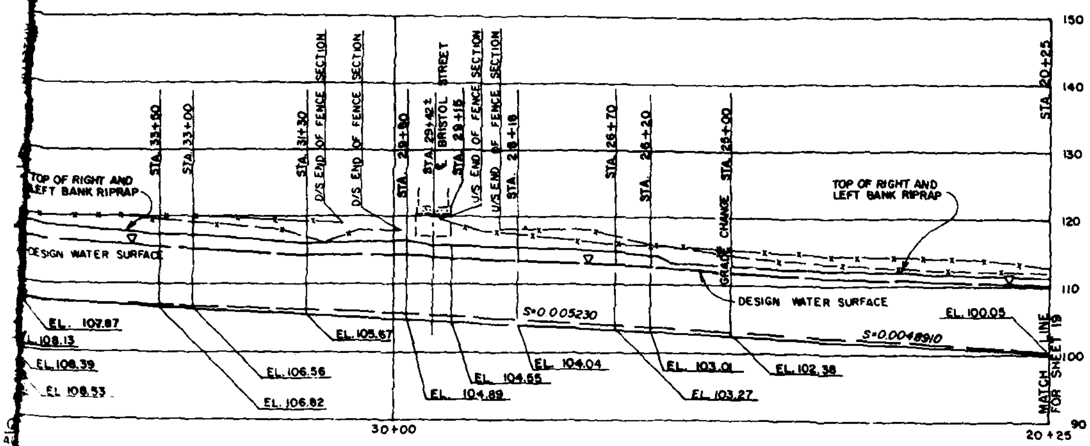


STA. 36+86±
SANTA ANA RIVER-SANTIAGO CREEK
CROSS SECTION AT BAKER ST.
PEDESTRIAN BRIDGE

NOTES:
1. ASSUME THIS CROSS SECTION FOR STAS. 36+90 AND 37+15
2. CROSS SECTION IS TAKEN LOOKING DOWNSTREAM.

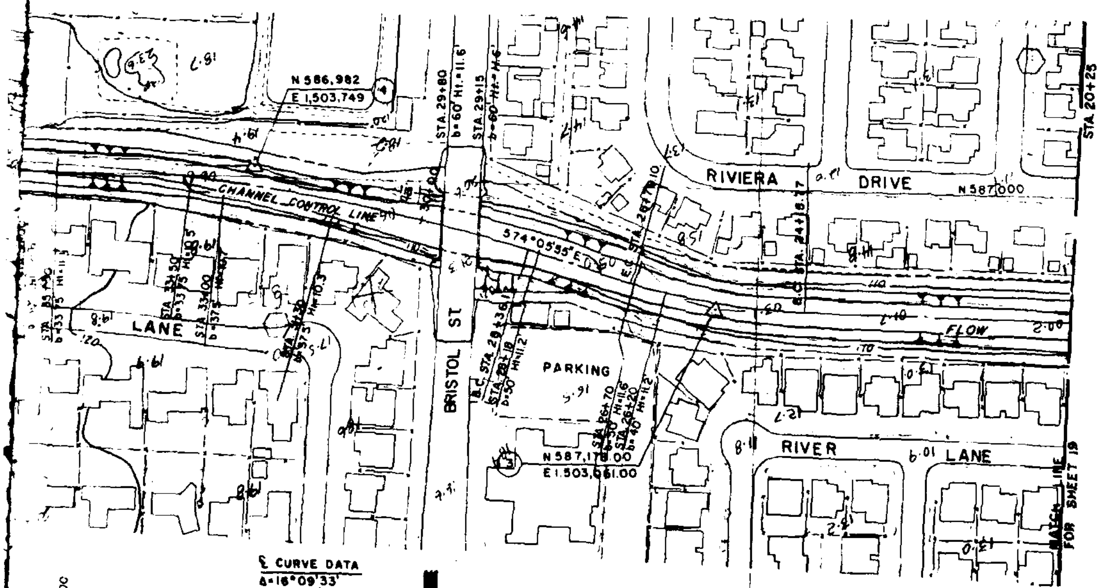
NOTES

1. UNLESS OTHERWISE SHOWN, TOP OF RIGHT AND LEFT BANK RIPRAP IS SAME AS DESIGN WATER SURFACE.
2. SYMBOL ——x—— DENOTES GROUND ELEVATION AT RIGHT BANK FENCE LINE
3. SYMBOL —x—x— DENOTES GROUND ELEVATION AT LEFT BANK FENCE LINE
4. HYDRAULIC ELEMENTS ARE DISPLAYED ON PLATE 21



PROFILE
HORIZ. SCALE: 1 IN. = 100 FT.
VERT. SCALE: 1 IN. = 10 FT.

℄ CURVE DATA
Δ=15°05'16"
R=1,000'
T=132.43'
L=263.33'



℄ CURVE DATA
Δ=16°09'33'
R=3,000'
T=425.87'
L=846.09'

PLAN
SCALE 1 IN = 100 FT.

LEGEND

- - - - - APPROXIMATE FLOODWAY BOUNDARY

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

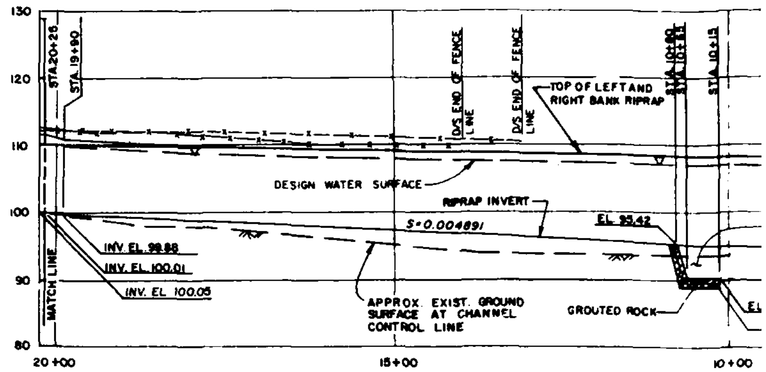
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL
PLAN AND PROFILE
STA. 49+40 TO STA. 20+25

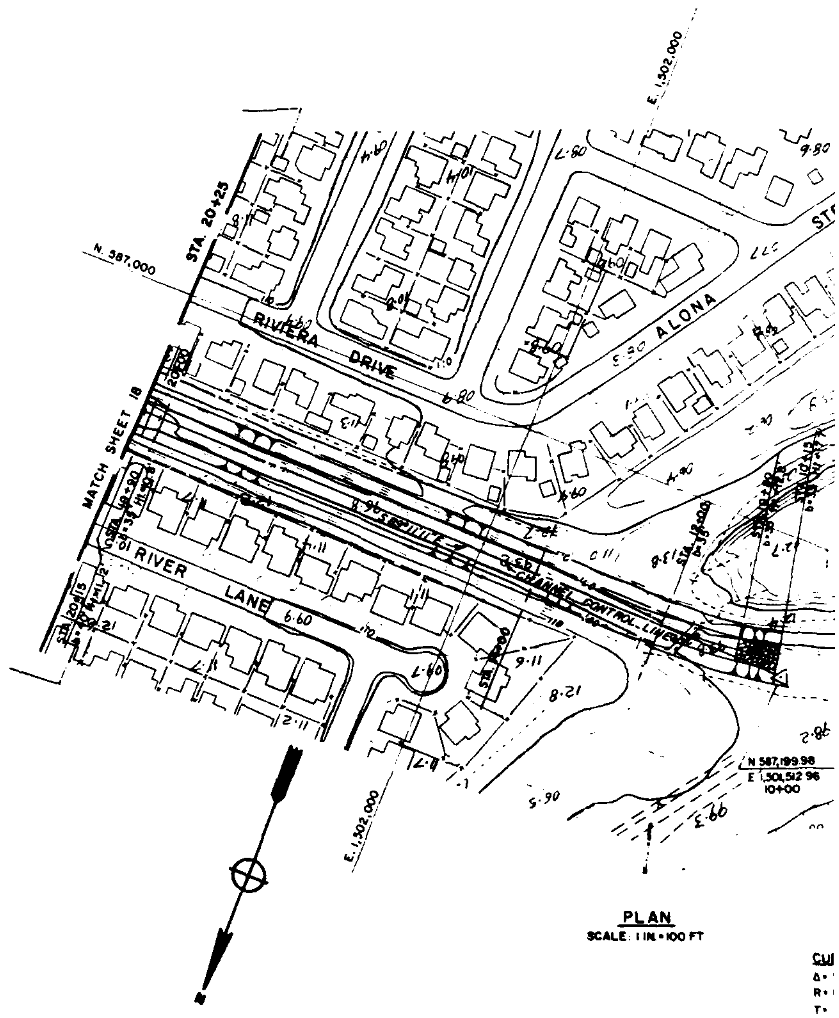
DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-___-B-____
DISTRICT FILE NO.
SHEET 2 OF 3 SHEETS

PLATE 18

VALUE I

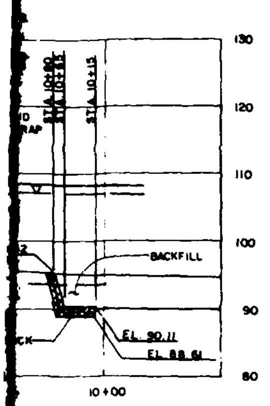


PROFILE
HORIZ. SCALE: 1 IN. = 100 FT.
VERT. SCALE: 1 IN. = 10 FT.

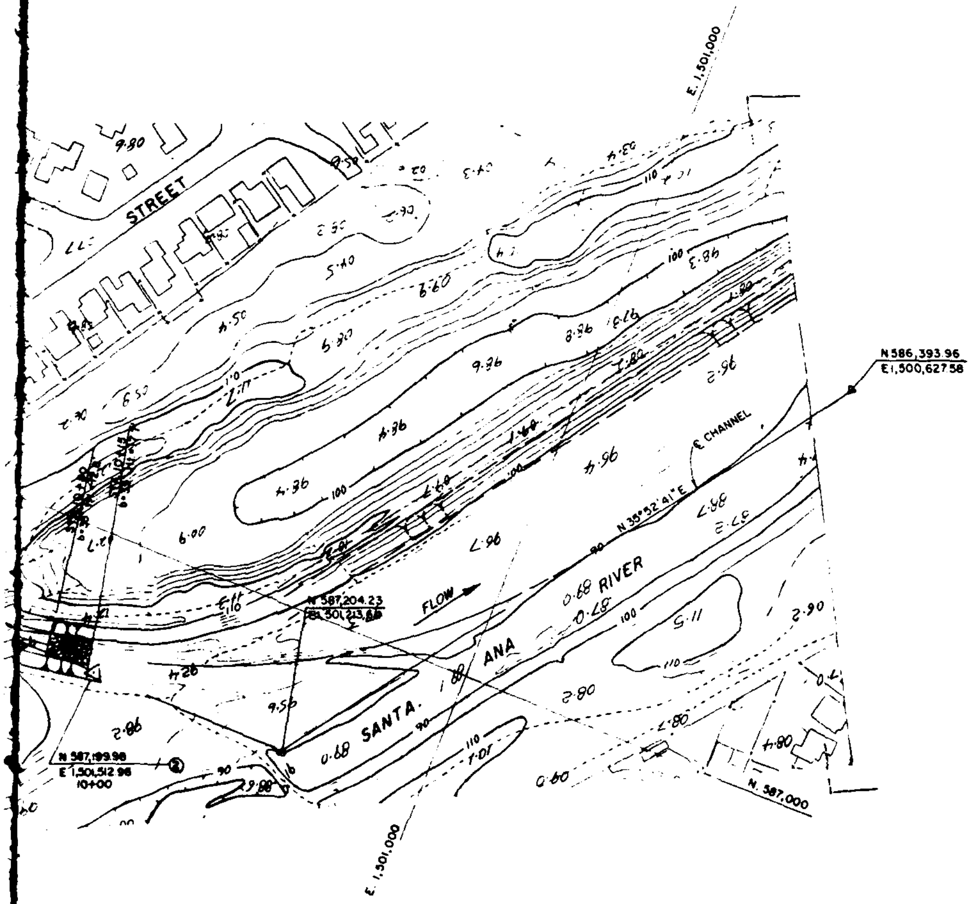


PLAN
SCALE: 1 IN. = 100 FT

SA



NOTES:
1. UNLESS OTHERWISE SHOWN, TOP OF RIGHT AND LEFT BANK RIPRAP IS SAME AS DESIGN WATER SURFACE.
2. SYMBOL ——x—— DENOTES GROUND ELEVATION AT RIGHT BANK FENCE LINE.
3. SYMBOL —x—x— DENOTES GROUND ELEVATION AT LEFT BANK FENCE LINE.
4. HYDRAULIC ELEMENTS ARE DISPLAYED ON PLATE 21.



LEGEND
— — — — — APPROXIMATE FLOODWAY BOUNDARY

CURVE DATA
Δ = 54°56'08"
R = 1000'
T = 519.85'
L = 958.82'

SCALE 10 0 10 20 30 FEET
SCALE 100 0 100 200 300 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

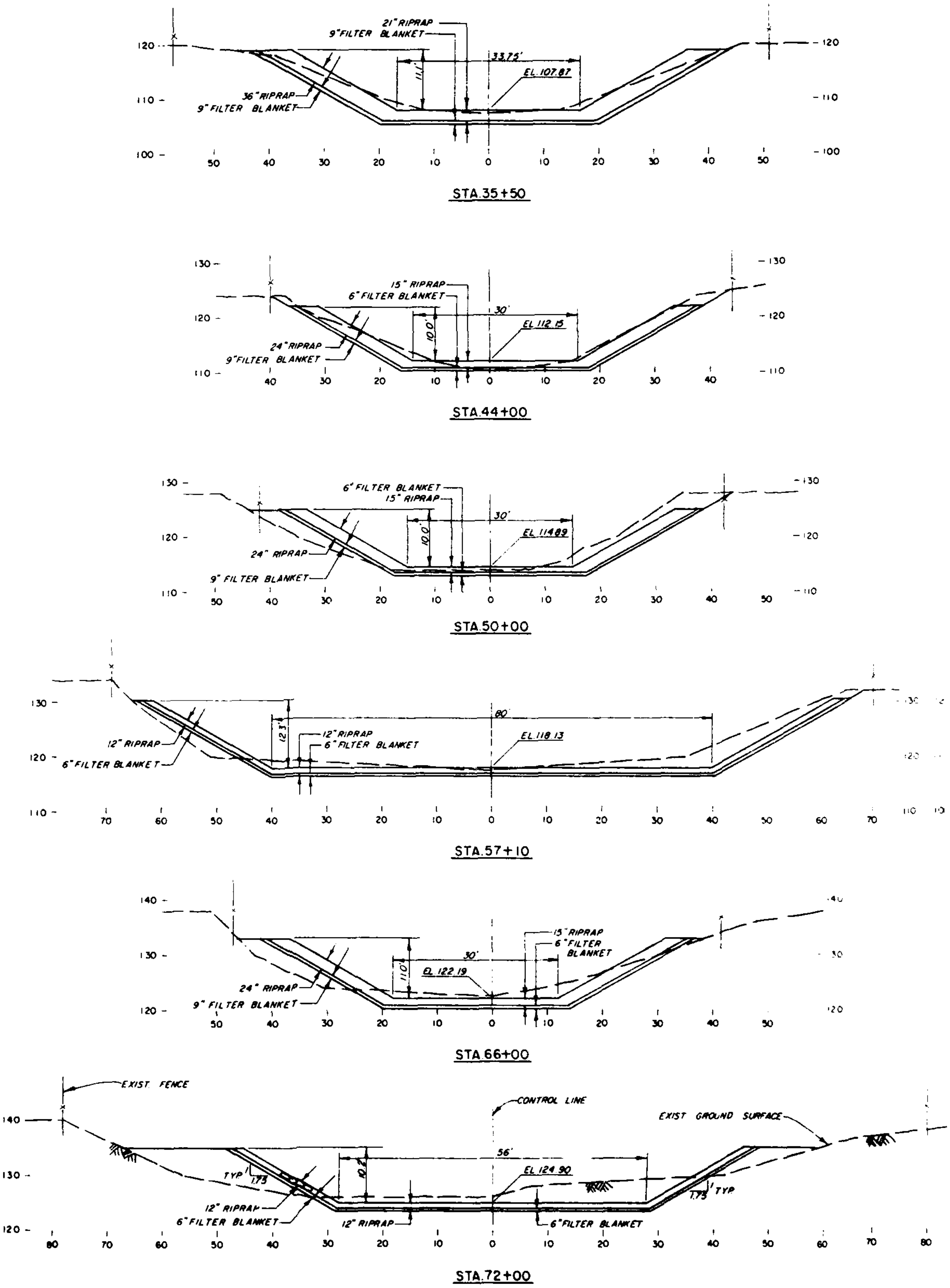
DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL
PLAN AND PROFILE
STA. 20+25 TO STA. 10+15

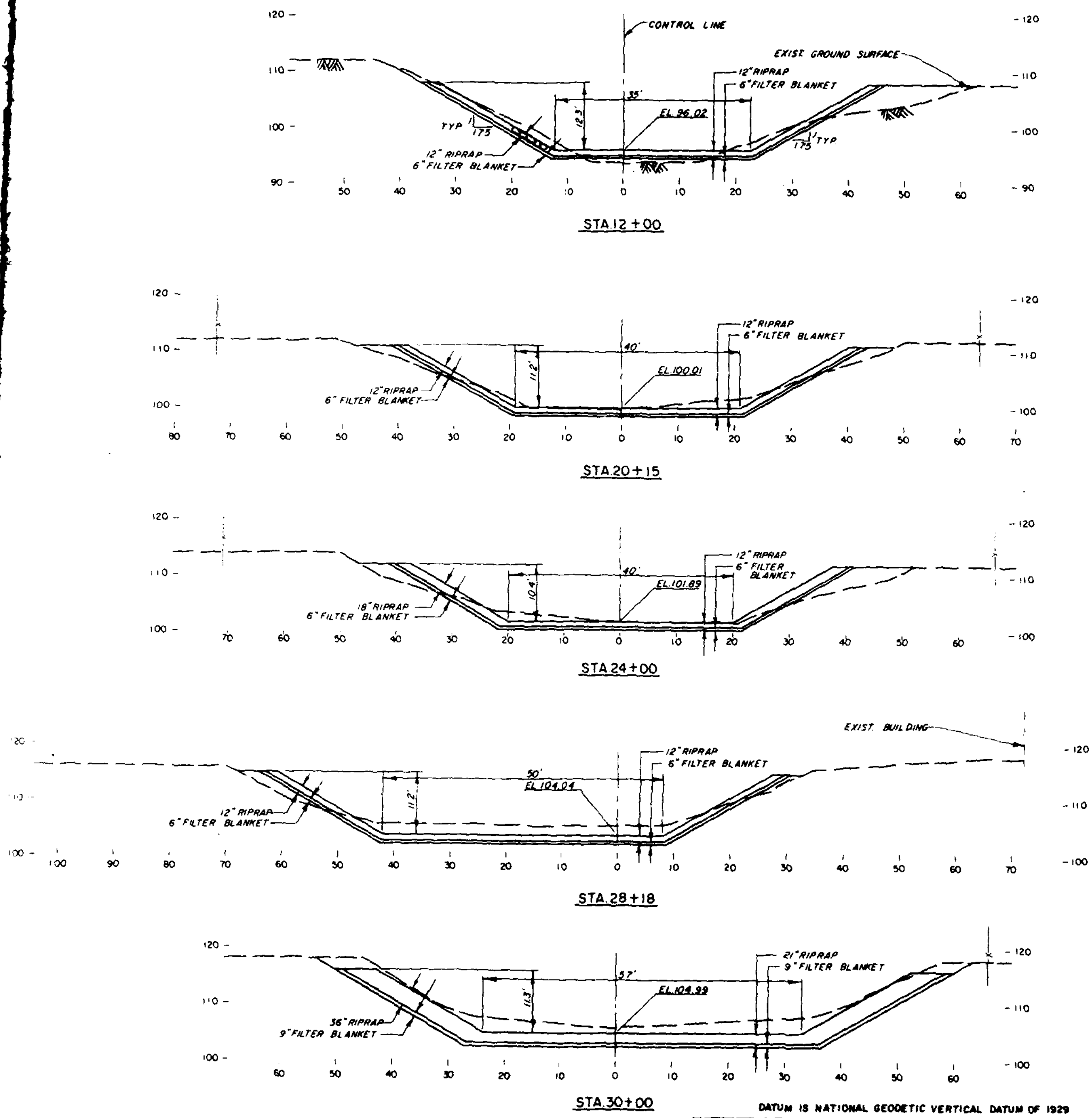
SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____ B-____
DISTRICT FILE NO.
SHEET 3 OF 3 SHEETS
PLATE 19

VALUE EI



21" RIPRAP
9" FILTER BLANKET
33.75'
11.1'
EL. 107.87
36" RIPRAP
9" FILTER BLANKET
STA.35+50
15" RIPRAP
6" FILTER BLANKET
30'
10.0'
EL 112.15
24" RIPRAP
9" FILTER BLANKET
STA.44+00
6" FILTER BLANKET
15" RIPRAP
30'
10.0'
EL 114.89
24" RIPRAP
9" FILTER BLANKET
STA.50+00
80'
12.3'
12" RIPRAP
6" FILTER BLANKET
EL 118.13
12" RIPRAP
6" FILTER BLANKET
STA.57+10
15" RIPRAP
6" FILTER BLANKET
30'
11.0'
EL 122.19
24" RIPRAP
9" FILTER BLANKET
STA.66+00
EXIST FENCE
CONTROL LINE
EXIST GROUND SURFACE
56'
EL 124.90
TYP
1.75
12" RIPRAP
6" FILTER BLANKET
12" RIPRAP
6" FILTER BLANKET
STA.72+00

SAF



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

NOTES
1. ALL CROSS SECTIONS DRAWN LOOKING DOWNSTREAM.
2. INVERT WIDTH VARIES FROM 30.0 FT. TO 80.0 FT. SEE PLAN.
3. INVERT RIPRAP THICKNESS VARIES FROM 12 IN. TO 21 IN.
4. SIDE SLOPE RIPRAP THICKNESS VARIES FROM 12 IN. TO 36 IN.
5. FILTER BLANKET THICKNESS IS 6 IN. OR 9 IN., DEPENDING UPON RIPRAP THICKNESS.

SCALE 10 0 10 20 30 FEET

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: D. CASTRO
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL
TYPICAL CROSS SECTIONS
STA. 72+00 TO STA. 12+00

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____ B-____
DISTRICT FILE NO.
SHEET 1 OF 1 SHEETS

HYDRAULIC ELEMENTS										
STATION	SLOPE	BOTTOM WIDTH (FT.)	CFS	Dc FT.	FOR RIPRAP THICKNESS			FOR WATER SURFACE		
					n	D (FT.)	V (FPS)	n	D (FT.)	V (FPS)
10+00	.0048910	35	5000	7.5	.029	10.2	9.2	.035	12.0*	9.1*
12+00	.0048910	35	5000	7.5	.029	9.8	9.8	.035	11.2*	9.4*
14+00	.0048910	35	5000	7.5	.029	9.5	10.2	.035	10.6*	9.6*
16+00	.0048910	35	5000	7.5	.029	9.4	10.4	.035	10.2*	9.7*
18+00	.0048910	35	5000	7.5	.029	9.3	10.4	.035	9.8*	9.7*
19+90	.0048910	35	5000	7.5	.029	9.3	10.4	.035	9.8	9.7
20+15	.0048910	40	5000	7.1	.029	9.8	9.0	.035	10.8	8.5
22+00	.0048910	40	5000	7.1	.029	9.2	9.7	.035	9.8	8.9
24+00	.005230	40	5000	7.1	.029	8.8	10.3	.035	9.4	9.4
25+00	.005230	40	5000	7.1	.029	8.6	10.5	.035	9.3	9.5
26+20	.005230	40	5000	7.1	.029	8.4	10.9	.035	9.2	9.7
26+70	.005230	50	5000	6.3	.029	9.1	8.3	.035	9.6	7.7
28+18	.005230	50	5000	6.3	.029	8.6	9.0	.035	9.2	8.2
29+15	.005230	60	5000	5.7	.029	8.7	7.7	.035	9.2	7.1
29+48	.005230	60	5000	5.7	.029	8.5	7.8	.035	9.6	6.8
29+80	.005230	60	5000	5.7	.029	9.1	7.3	.035	9.5	6.9
31+30	.005230	37.50	5000	7.3	.033	7.7	12.7	.035	8.3	11.5
33+00	.005230	37.50	5000	7.3	.033	8.6	11.2	.035	8.7	10.8
33+50	.005230	33.75	5000	7.7	.033	8.3	12.6	.035	8.5	12.0
35+50	.005230	33.75	5000	7.7	.032	8.6	11.3	.035	9.2	10.9
36+00	.005230	30	5000	8.1	.032	8.6	12.9	.035	8.9	12.3
36+50	.005230	30	5000	8.1	.032	9.0	12.1	.035	9.3	11.7
36+75	.005230	30	5000	7.9	.032	8.9	12.6	.035	9.2	12.2
36+90	.005230	30	5000	7.9	.031	9.0	12.5	.035	9.2	12.1
37+15	.005230	30	5000	8.1	.031	9.4	11.4	.035	9.7	11.0
39+00	.005230	30	5000	8.1	.031	9.3	11.6	.035	9.7	10.9
41+50	.005230	30	5000	8.1	.031	9.3	11.7	.035	9.7	10.9
43+00	.0045660	30	5000	8.1	.031	9.5	11.3	.035	9.9	10.6
45+00	.0045660	30	5000	8.1	.031	9.5	11.3	.035	10.1	10.4
47+00	.0045660	30	5000	8.1	.031	9.5	11.3	.035	10.1	10.4
49+00	.0045660	30	5000	8.1	.031	9.5	11.3	.035	10.1	10.4
51+00	.0045660	30	5000	8.1	.031	9.5	11.3	.035	10.1	10.4
53+00	.0045660	30	5000	8.1	.031	9.5	11.3	.035	10.0	10.4
55+00	.0045660	30	5000	8.1	.031	9.5	11.3	.035	10.1	10.4
55+93	.0045660	30	5000	8.1	.031	9.5	11.3	.035	10.1	10.4
57+28	.0045660	80	5000	4.8	.029	10.8	4.6	.035	11.3	4.4
57+63	.0045660	80	5000	4.8	.029	10.9	4.7	.035	11.2	4.5
59+13	.0045660	40	5000	7.1	.029	9.7	9.0	.035	10.2	8.5
62+09	.0045660	40	5000	7.1	.030	9.4	11.4	.035	9.7	9.1
62+59	.0045660	30	5000	8.1	.030	9.3	11.6	.035	9.0	12.1
63+00	.0045660	30	5000	8.1	.030	9.3	11.6	.035	9.3	11.6
65+00	.0045660	30	5000	8.1	.030	9.3	11.6	.035	9.9	10.7
67+00	.0045660	30	5000	8.1	.031	9.4	11.4	.035	10.0	10.5
68+00	.0045660	30	5000	8.1	.031	9.5	11.3	.035	10.1	10.4
69+00	.0045660	50	5000	6.3	.029	10.6	6.9	.035	11.0	6.6
70+00	.0045660	50	5000	6.3	.029	10.2	7.2	.035	10.7	6.8
70+30	.0045660	56	5000	5.9	.029	10.3	6.6	.035	10.7	6.2
72+00	.0045660	56	5000	5.9	.029	9.6	7.1	.035	10.1	6.7
74+35	.0045660	56	5000	5.9	.029	8.9	7.8	.035	9.5	7.2

* CONTROLLING Q = 4000 cfs with contemporaneous flow in the Santa Ana River

CHANNEL CONSTRUCTION ELE				
STATION	INVERT WIDTH (FT.)	SIDE SLOPE HEIGHT (FT.)	RIPRAP THICKNESS	
			INVERT (IN.)	SIDE SLOPES (IN.)
10+15	35.0	17.7	1	12
10+65	35.0	17.7	1	12
10+80	35.0	12.8	1	12
12+00	35.0	12.3	12	12
14+00	35.0	11.7	12	15
16+00	35.0	11.2	12	15
18+00	35.0	10.9	12	15
19+90	35.0	10.8	12	15
20+15	40.0	11.2	12	12
22+00	40.0	10.8	12	18
24+00	40.0	10.4	12	18
25+00	40.0	10.3	12	21
26+20	40.0	11.2	12	21
26+70	50.0	11.6	12	12
28+18	50.0	11.2	12	12
29+15	60.0	11.3	12	12
29+48	60.0	11.1	12	12
29+80	60.0	11.5	21	36
31+30	37.5	10.3	21	36
33+00	37.5	10.7	21	36
33+50	33.75	10.5	21	36
35+50	33.75	11.1	21	36
36+00	30.0	10.9	21	36
36+50	30.0	9.3	18	30
36+75	30.0	9.2	18	30
36+90	30.0	9.2	18	30
37+15	30.0	9.7	15	24
39+00	30.0	9.7	15	24
41+50	30.0	9.7	15	24
43+00	30.0	9.9	15	24
45+00	30.0	10.1	15	24
47+00	30.0	10.1	15	24
49+00	30.0	10.1	15	24
51+00	30.0	10.1	15	24
53+00	30.0	10.0	15	24
55+00	30.0	11.1	15	24
55+93	30.0	11.1	15	24
56+93	80.0	12.3	12	12
57+28	80.0	12.3	12	12
57+63	80.0	12.2	12	12
59+13	40.0	10.2	12	15
62+09	40.0	9.7	15	24
62+59	30.0	9.1	15	24
63+00	30.0	9.4	15	24
65+00	30.0	10.9	15	24
67+00	30.0	11.0	15	24
68+00	30.0	11.1	15	24
69+00	50.0	11.0	12	12
70+00	50.0	10.7	12	12
70+30	56.0	10.7	12	12
72+00	56.0	10.2	12	12
74+35	56.0	9.5	12	12

1 Invert is 18-inch thick grouted rock from Sta 10+ 5

UE ENGINEERING PAYS

STRUCTION ELEMENTS		
THICKNESS	FILTER BLANKET THICKNESS	
SIDE SLOPES (IN.)	INVERT (IN.)	SIDE SLOPES (IN.)
12	–	6
12	–	6
12	–	6
12	6	6
15	6	6
15	6	6
15	6	6
15	6	6
12	6	6
18	6	6
18	6	6
21	6	9
21	6	9
12	6	6
12	6	6
12	6	6
2	6	6
36	9	9
36	9	9
36	9	9
36	9	9
36	9	9
36	9	9
30	6	9
30	6	9
30	6	9
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
2	6	6
12	6	6
2	6	6
5	6	6
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
24	6	9
12	6	6
2	6	6
12	6	6
12	6	6
12	6	6

from Sta.10+15 to Sta.10+80

TABULATION OF GROUND ELEVATIONS AT BASE OF FENCE LINE(S)					
STA.14+00 TO STA.74+36 LEFT BANK (LOOKING DOWNSTREAM)			STA.13+11 TO STA.74+36 RIGHT BANK (LOOKING DOWNSTREAM)		
STATION	ELEVATION (FT.)	REMARKS	STATION	ELEVATION (FT.)	REMARKS
14+00	109.9	downstream end of fence line.	13+11	110.2	d/s end of fence line.
16+00	109.9		18+00	112.0	
18+58	112.0		19+17	112.0	
19+43	112.0		19+59	112.0	
21+38	114.0		21+02	112.0	
23+38	114.4		22+45	112.5	
26+84	116.0		24+66	114.0	
28+76	118.0		26+27	116.0	
29+15	–	d/s edge of Bristol St. bridge.	27+12	118.0	
29+30	119.7	u/s end of fence section.	28+43	118.0	u/s end of fence section.
29+68	–	u/s edge of Bristol St. bridge.	29+15	–	d/s edge of Bristol St. bridge
30+73	119.0	d/s end of fence section	29+68	–	u/s edge of Bristol St. bridge.
33+00	120.0	and corner of building.	29+86	118.0	d/s end of fence section.
35+46	120.0		30+50	118.0	
36+65	120.0	18-ft. d/s of pedestrian bridge.	31+06	116.2	
37+09	120.0	21-ft. u/s of pedestrian bridge.	31+68	118.0	
38+39	122.0		34+07	120.0	
40+00	122.0		36+81	120.0	at pedestrian bridge.
41+43	122.0		37+14	120.0	
42+38	124.0		38+57	122.0	
44+37	124.0		39+24	122.0	
45+17	124.0		41+46	124.0	
46+00	126.0		44+10	126.0	
47+96	124.0		46+25	126.0	
49+67	124.0		46+88	126.0	
50+51	126.0		48+45	126.0	
50+80	128.0		49+06	128.1	
52+30	128.0		51+00	130.0	
53+33	130.0		51+53	130.0	
54+17	130.0		51+92	128.0	
54+74	132.0		52+75	126.3	
55+04	134.0		53+71	128.0	
56+00	132.0	u/s end of fence section.	55+08	128.0	
56+85	–	d/s edge of Flower St. bridge.	55+50	127.0	
57+03	130.0	d/s end of fence section	55+81	128.0	
57+53	–	u/s edge of Flower St. bridge.	56+09	130.0	
58+03	132.0		56+42	132.0	
58+34	134.0		56+79	132.0	
59+58	128.0		56+85	–	d/s edge of Flower St. bridge
60+63	128.0		57+25	132.1	u/s end of fence section
61+16	130.0		57+53	–	u/s edge of Flower St. bridge
64+00	136.0		59+40	134.0	d/s end of fence station.
65+27	138.0		61+05	134.5	
66+28	138.0		62+28	134.0	
70+63	140.0		62+59	136.0	
72+13	140.0		64+07	136.0	
72+36	142.0		64+44	132.0	
72+68	142.0		65+00	132.0	
73+16	140.0		66+00	134.0	
73+33	142.0		66+28	136.0	
73+72	142.0		66+46	138.0	
74+16	139.0	u/s end of fence section	67+95	138.0	
74+36	–	d/s edge of Santa Ana Frwy.	68+55	139.0	
			69+04	140.0	
			69+63	138.0	
			69+92	138.0	
			70+11	140.0	
			70+46	140.0	
			70+76	138.0	
			71+33	130.0	
			71+42	138.0	
			72+00	138.0	
			72+62	140.0	
			73+62	140.0	
			74+36	–	d/s edge of Santa Ana Frwy.

D/S – DOWNSTREAM
U/S – UPSTREAM

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

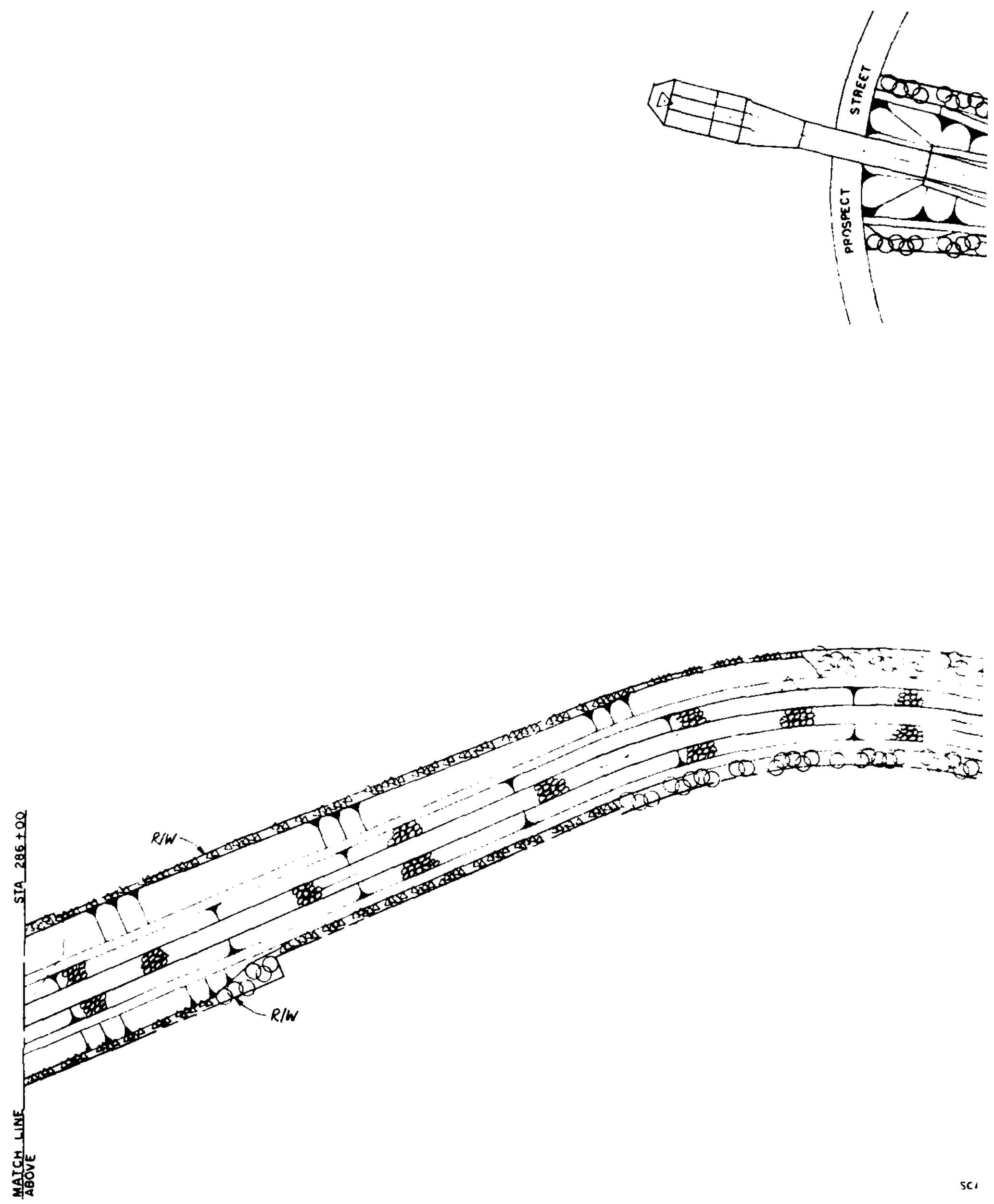
SANTIAGO CREEK CHANNEL

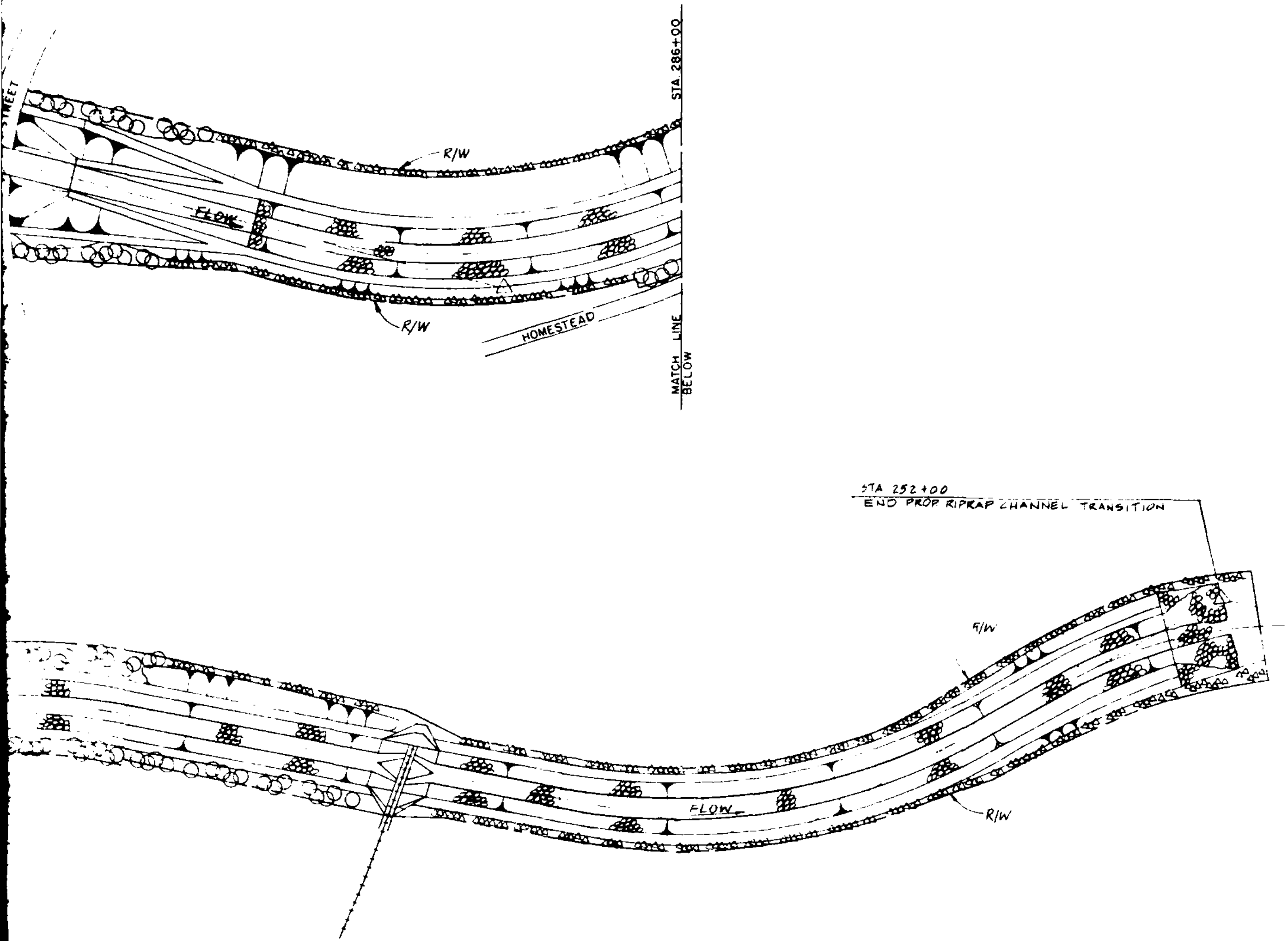
HYDRAULIC ELEMENTS STA 10+00 TO STA 74+35
CONSTRUCTION ELEMENTS STA 10+15 TO STA 74+35
GROUND ELEVATION AT BASE OF FENCELINE
STA. 13+11 TO STA. 74+36

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW 09- ____ B- ____
DISTRICT FILE NO
SHEET

Y SAFETY PAYS

VALUE





PLAN
SCALE 1 IN = 100 FT

LEGEND

Typical Tree Grouping

Typical Shrub Grouping

SCALE 100 0 100 200 300 FEET

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL

DRAWN BY: PP ENGUETA

CHECKED BY:

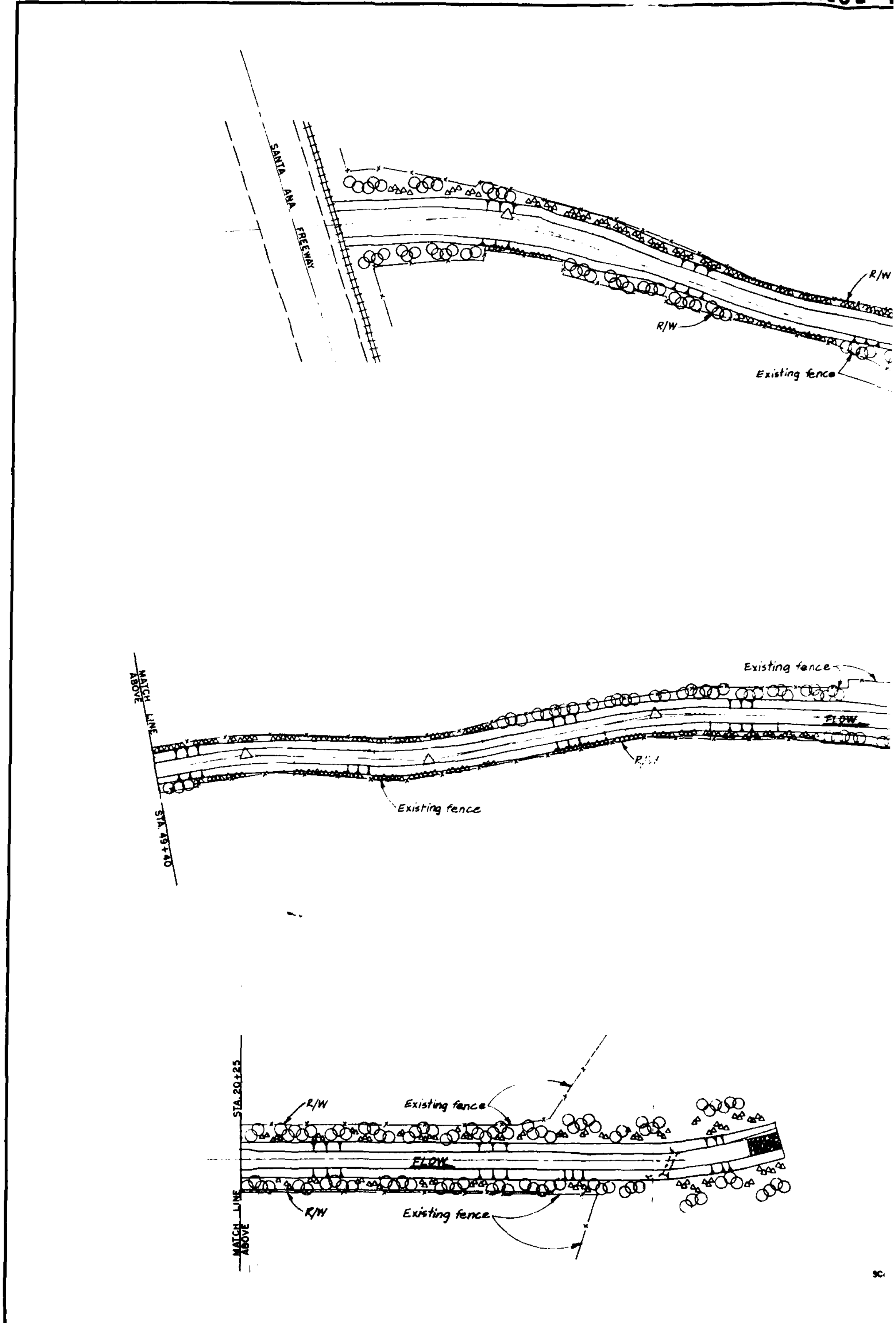
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL
ESTHETIC TREATMENT PLAN
(STA.300 +12 TO STA 286+00)
(STA 286 +00 TO STA 252+00)

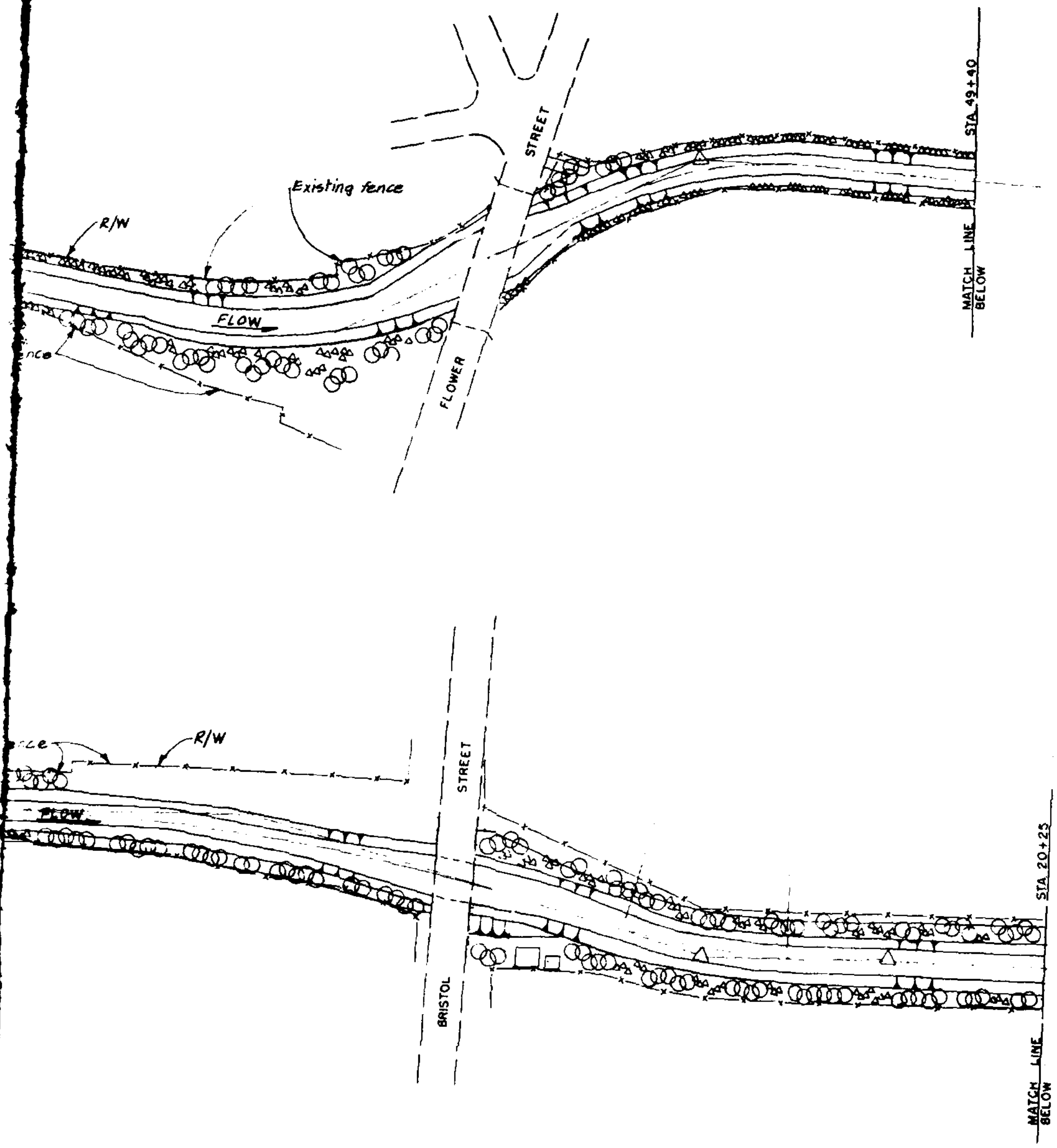
SUBMITTED BY: | DATE APPROVED: | SPEC NO. DACW09- ____ B- ____ | SHEET

DISTRICT FILE NO

VALUE I


SANTA ANA FREEWAY
R/W
R/W
Existing fence
Existing fence
MATCH LINE ABOVE
STA. 49+40
FLOW
Existing fence
STA. 20+25
R/W
Existing fence
FLOW
MATCH LINE ABOVE
R/W
Existing fence

S/



LEGEND

Typical Tree Grouping

Typical Shrub Grouping

PLAN
SCALE: 1 IN. = 100 FT.

SCALE 100 0 100 200 300 FEET

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: P. PENALUETA

CHECKED BY:

SANTIAGO CREEK RESERVOIR
ESTHETIC TREATMENT PLAN
STA 77+70 TO STA. 49+40
STA 49+40 TO STA. 20+25
STA. 20+25 TO STA. 9+35

SUBMITTED BY:

DATE APPROVED:

SPEC. NO. DACW 09-___ B-____

DISTRICT FILE NO.

SHEET

A GEOTECHNICAL

SANTIAGO CREEK, CALIFORNIA

PHASE II GENERAL DESIGN MEMORANDUM

APPENDIX A, GEOTECHNICAL

U.S. ARMY CORPS OF ENGINEERS

LOS ANGELES DISTRICT

AUGUST 1988

CONTENTS

Contents (Continued)

Tables

Contents (Continued)

Tables (Continued)

Figures

Plates

I. INTRODUCTION

Purpose and Scope

1-01 Geologic and soils research and field investigations were conducted in order to determine the geology, groundwater, and foundation conditions at the site of the Santiago Creek project. This appendix describes the geotechnical explorations and testing performed, the foundation conditions in the project area, and the soil parameters to be used in the project design. Recommendations are given for foundation treatment, embankment design, and construction applications.

Location

1-02 Santiago Creek flows southwest into the Lower Santa Ana River through the cities of Orange and Santa Ana in Orange County. This appendix covers the Bond and Blue Diamond Gravel Pits and approximately 5.5 miles of the lower reaches of the creek from its confluence with the Lower Santa Ana River to Prospect Street. Plate A-1 shows the location of the project.

Site Description

1-03 Santiago Creek is a fairly shallow ephemeral stream, dry except during floodflows, with mild gradients. The creek winds through a densely populated area with residential structures close on either bank. The Bond and Blue Diamond Pits are large commercial excavations approximately 140 feet deep and covering an area of about 250 acres.

Description of Proposed Project

1-04 Improvements proposed for the channel consist of enlarging the existing creek to a larger trapezoidal cross-section at stations 293+15 to 252+00 and stations 74+35 to 10+15. This would include flattening the slopes and deepening the invert. The slopes and invert would be revetted with either riprap or grouted stone. The Bond and Blue Diamond Gravel Pits will serve as flood detention basins. Improvements to the gravel pits include constructing a gated outlet structure at Prospect Street. Buttress construction to stabilize existing gravel pit slopes will be carried out by the Orange County Water District for a water storage and groundwater recharge facility (elevation 160-300 feet) before completion of the flood control facility (elevation 270-298 feet) by the Corps of Engineers.

II. GEOLOGY

Topography and Geology

2-01 The proposed channel improvements along the lower reaches of Santiago Creek are located in the southeastern portion of the Los Angeles basin. This basin, which forms the northern portion of the Peninsular Ranges geomorphic province, is a deep structural depression that has subsided over time and accumulated upwards of approximately 30,000 feet of predominantly marine Cretaceous to Holocene (Recent) age sediments. Santiago Creek, a major tributary to the Santa Ana River, originates on the western slopes of the Santa Ana Mountains and flows in a general westerly direction for about 25 miles to its confluence with the Santa Ana River in the city of Orange. Streamflows are now partially regulated by the Santiago and Villa Park Dams several miles upstream from the project area. In the upper reaches of Santiago Creek the depth to the channel floor is shallow and very irregular, ranging from 15 to 40 feet. Downstream of Villa Park Dam, where the channel leaves the relatively narrow confines of the highlands and turns southwestward onto the floodplain, the relatively coarse alluvial fan deposits of Quaternary age thicken considerably, to perhaps an average thickness of as much as 540 feet (Miller and Corbaley, 1981). At the upstream end of the project area, deep gravel pits have been excavated in cobbley gravelly sands. Progressively finer sediments have been encountered in borings downstream. Just upstream from the project area, the active creek channel is bounded by Quaternary age terrace deposits resulting from older stream activity. Flanking these older terrace deposits are complex associations of folded and faulted Tertiary sediments and volcanics. A geologic map of the project area is shown on plate A-2.

Faulting and Seismicity

2-02 The proposed channel improvements, from the Bond and Blue Diamond gravel pits to the confluence with the Lower Santa Ana River, are situated on the thick Recent and Pleistocene age alluvial deposits of the Los Angeles basin. No faulting has been positively identified under the project area. However, Santiago Creek is surrounded by active or historically active faults capable of generating earthquakes which could cause seismic shaking along the channel. The most significant of these seismotectonic features, the Newport-Inglewood, Whittier-Elsinore and San Andreas fault zones, are as close as 7 miles southwest, 7 miles north, and 35 miles northeast of the project area, respectively, Both the Newport-Inglewood and Whittier-Elsinore faults could generate maximum credible earthquakes of Richter magnitude 7.0 to 7.5. This would result in corresponding maximum bedrock accelerations between 0.45 and 0.50 g at the project site (after Greensfelder, 1974). With a magnitude 8-plus event on the San Andreas fault, attenuation of ground motions would produce a maximum acceleration in rock of only 0.25 g at the site (after Schnabel and Seed, 1973). In both cases, the maximum ground accelerations developed in the alluvial deposits in the project area would be less than those values stated for rock according to Seed and others (1976).

2-03 Two separate faults of undetermined significance have been mapped within 1-1/2 miles of the upstream end of the project. The Peralta Hills fault is an east-trending, north-dipping thrust fault located north of the project area (see pl. A-2). The fault has a mapped surface trace of more than 5 miles and if it were to undergo surface rupture along half its length, the associated earthquake would be in the Richter magnitude 5.5 to 6.0 range. However, the Peralta Hills fault could represent only a surficial flexural-slip reverse fault which is related to the regional tectonics but is incapable of generating a large magnitude earthquake. The other locally mapped fault shown on plate A-2 is the El Modeno fault, a northwest-trending, steeply-dipping normal fault which is inferred to cross Santiago Creek upstream of the project area. The fault trace segments lie separated by short expanses of alluvial materials but may in fact be connected into a continuous and discrete feature (Ryan et al., 1982). There is some evidence suggesting that both the El Modeno and Peralta Hills faults may displace Holocene (Recent) alluvium (Morton et al., 1976; Bryant and Fife, 1982; Ryan et al., 1982). The trace of the northern portion of the El Modeno fault has not been precisely located. Its trend may lie parallel to that of the Peralta Hills as shown on plate A-2, or the fault, as Bryant and Fife (1982) suggest, may be truncated by or pass beneath the Peralta Hills fault.

2-04 Santiago Creek is in an area of high seismic potential. More than 150 earthquakes, with Richter magnitudes equal to or greater than 4.0, have been recorded within a 25-mile radius of the project area between February 1932 and January 1987. Most of these events had magnitudes less than 5.0 and were aftershocks of the 1933 Long Beach earthquake. Only one magnitude 4-plus earthquake has been recorded in the immediate project area. This event, in 1936, had a Richter magnitude of 4.0 and an epicenter location approximately 1 mile southeast of Santiago Creek at its closest extent (see pl. A-2). The most significant earthquake to occur locally was the Long Beach event, with a Richter magnitude of 6.3 and an epicenter location approximately 12 miles south of the downstream limits of the project. This event would have produced an acceleration of about 0.2 g in the vicinity of the project.

2-05 Santiago Creek is located in Seismic Zone 4 as indicated by Figure 6A of EM 1110-2-1902, "Stability of Earth and Rockfill Dams." In accordance with the preceding discussion and EM 1110-2-1902, the seismic probability is great and a seismic coefficient of 0.15 should be used in slope stability analyses for Santiago Creek.

Groundwater

2-06 The Santiago Creek channel improvements lie within the Orange County groundwater basin. Groundwater information for the project area was obtained from Orange County Water District (OCWD) groundwater contour maps (OCWD, 1987), water well records compiled by the California Department of Water Resources, and Robbins (1986). Water well data were used to develop groundwater profiles along Santiago Creek which are shown on plate A-3. The highest and lowest groundwater elevations are depicted for key wells along the project. In addition, three generalized water level profiles, two derived from OCWD, November 1984 and November 1986, groundwater contour maps and one derived from a November 1984 shallow groundwater contour map by Robbins (1986), are shown. The upper 1984 profile represents the approximate level of the shallow or "semiperched" zone typically found throughout the basin while the lower 1984 profile and the 1986 profile are composites of water levels from the various deeper fresh water aquifers. The depth to groundwater along Santiago Creek decreases in a downstream direction, from approximately 150 feet (elevation, 150 feet) in state well 4S/9W-28H2 near the gravel pits to 65 feet (elevation, 50 feet) in state well 5S/10W-2B2 near the confluence with the Santa Ana River. These depths represent the highest recorded levels through 1986 and during most years, the groundwater elevations tend to be slightly to significantly lower. In November 1986, water levels in the deep aquifers ranged from depths of about 270 feet near the gravel pits to about 100 feet at the Santa Ana River confluence. Limited data available for the shallow groundwater zone indicate that water levels in the shallow zone are currently about 80 feet higher on the average than corresponding water levels in the deeper zone. During explorations conducted by the Orange County Environmental Management Agency (1976) at the Bond Gravel Pit and by the Corps of Engineers downstream near the Santa Ana River in 1979, groundwater, possibly representative of the semiperched zone, was encountered at depths below 20 feet in borings B-2 and TH 79-1 (see pls. A-4 and A-19). In addition, localized bodies of perched water were also encountered during the Bond pit investigation. These bodies of perched water should not pose any significant problems during construction since regional groundwater levels are well below the influence of construction activities.

III. FIELD INVESTIGATIONS

Corps of Engineers Exploration of Channel

3-01 Exploration for the proposed channel improvements consisted of drilling seven test holes, TH79-1 through TH79-7, on the top of the channel slopes and digging eleven test trenches, TT83-1 through TT83-11, in the channel invert. The test holes were drilled to a depth of 30 feet with a 24-inch diameter bucket auger during October 1979. The test trenches were excavated using a backhoe equipped with a 24-inch bucket during September 1983. The locations of the test holes and test trenches, and logs of exploration are shown on plates A-4 through A-13. The materials encountered were visually classified. Disturbed samples of representative material types were obtained at intervals of 5 feet, or at more frequent intervals, for laboratory testing. Standard penetration tests (SPT) were performed within each test hole. SPT blow counts are recorded on the logs of exploration.

Corps of Engineers Exploration of Gravel Pits

3-02 The exploration for the proposed gravel pit improvements consisted of sampling the walls of the pits, making visual observations, and logging observations at five locations identified as TL79-8 through TL79-12. The locations sampled along the gravel pit walls which apply to the current conditions in the gravel pits are shown on plate A-14. The logs are shown on plate A-15.

Supplemental Explorations

3-03 Investigations of the Bond and Blue Diamond Gravel Pits were conducted by Woodward-Clyde Consultants during April 1985. Their explorations included eight borings, B-1 through B-8, seven test pits, TP-1 through TP-7, and twelve cone penetration tests (CPT). A hollow stem auger drill rig was used to drill the boreholes to depths between 10 and 67 feet. A Case 200 backhoe was used to excavate the test pits to depths between 5 and 14 feet. The locations of the borings and test pits are shown on plate A-14. The boring logs are shown on plate A-16 and the test pit logs are shown on plate A-17. In addition, hand samples were obtained from the gravel pit walls and stratigraphic columns were developed at four locations. The locations of the stratigraphic columns are shown on plate A-14 and the columns are shown on plate A-18. Planning Research Corporation Engineering (PRC) conducted an investigation of the Bond and Blue Diamond Pits during December 1984 and developed generalized stratigraphic columns shown on plate A-18 for the Bond and Blue Diamond Pits. In March 1976, the Orange County Environmental Management Agency (OCEMA) conducted their own investigation of the Bond and Blue Diamond Gravel Pits. The investigation consisted of eight borings, B-1 through B-8. The boring locations are shown on plate A-14 and the logs are shown on plate A-19.

IV. LABORATORY TESTING

Corps of Engineers Testing

4-01 Mechanical analyses, Atterberg limits, and moisture content determinations were conducted on all disturbed samples retrieved by the Corps of Engineers. Compaction tests were conducted on representative samples. Testing was conducted in accordance with EM 1110-2-1906, "Laboratory Soils Testing."

Testing by Others

4-02 Woodward-Clyde performed tests on selected samples from their explorations. These included moisture content, dry density, mechanical analysis, Atterberg limits, unconfined compression, corrosivity, and consolidation tests. Testing conducted by OCEMA included mechanical analysis, moisture content, compaction, shear strength, and permeability tests.

V. FOUNDATION CONDITIONS

Channels

5-01 The logs of exploration indicate that the materials along the channel alignment consist primarily of loose to medium dense gravelly sands, silty gravelly sands, and silty sands with cobbles and boulders up to 14 inches in diameter. Stiff to very stiff sandy clay and sandy silt layers varying in thickness from 1 to 5 feet are also present along the channel alignment. Typical SPT blow counts in the channel bank range from 10 to 18 blows per foot for cohesive materials and 7 to 25 blows per foot for cohesionless materials.

Gravel Pits

5-02 The logs of exploration indicate that the materials in the gravel pits consist primarily of medium dense to dense gravelly sand and sandy gravel. Frequent cobbles typically range from 9 to 12 inches. Occasional lenses of sandy clay, sandy silt, and clay, with a consistency ranging from very soft to stiff are present in the gravel pit area in thicknesses ranging from 0.5 to 8 feet.

VI. ANALYSIS

Channel Analysis

DESIGN VALUES

6-01 Values for design and analysis of the Santiago Creek channel were selected based on conservative interpretation of the laboratory and field data and past experience on other Corps of Engineers projects. The majority of materials above the proposed invert consist of gravelly sands and silty sands. Drained angles of internal friction for these materials would range from 35 to 40 degrees. There are occasional layers of fine-grained materials, consisting of sandy clay, which are designated as stiff to very stiff. These fine-grained materials would not significantly affect the factors of safety for the channel slopes. The channel design values are presented in table A-1 below.

Table A-1. Channel Design Values.

	In situ Material	Compacted Fill
Dry Unit Weight, (pcf)	120	115
Moist Unit Weight, (pcf)	130	125
Saturated Unit Weight, (pcf)	138	133
Drained Angle of Internal Friction, (deg)	35	35
Permeability, (fpd)	10	0.1
Coefficient of Active Earth Pressure,	0.3	0.3
Equivalent Earth Fluid, (pcf)	39	37

SLOPE STABILITY

6-02 The stability of the channel side slopes was determined in general accordance with EM 1110-2-1902, "Stability of Earth and Rockfill Dams," except for the rapid drawdown condition which was analyzed using a one-step, effective stress analysis. The slopes were analyzed for static and seismic loading as well as rapid drawdown conditions. Table I of EM 1110-2-1902 requires minimum factors of safety of 1.0, 1.0, and 1.5 for rapid drawdown, seismic, and long-term static conditions, respectively. A seismic coefficient of 0.15, corresponding to seismic zone 4, was used for the seismic loading condition. The steepest allowable channel slope satisfying the minimum factor of safety requirements is 1V on 1.75H. The slope geometry at station 12+00, where the levee reaches its maximum height with the lightest riprap section, and results of the stability analysis are presented in figures A-1 and A-2.

REVETMENT

6-03 The channel side slopes will be protected against erosion by riprap varying in thickness from 12 to 36 inches. The channel invert will be revetted with riprap varying in thickness from 12 to 21 inches. Filter material to prevent erosion of the underlying foundation soils will be required beneath the stone layers.

Reservoir Analysis (Bond Avenue Gravel Pit)

DESIGN VALUES

6-04 Values for design and analysis of the reservoir slopes are based on conservative interpretations of the field and laboratory data and on the stability of the existing slopes. The angle of internal friction of the native alluvial materials was based in part on back-calculations of slope stability given the known slope steepness of 1V on 0.8H. Consideration was given to design values selected for similar material on major projects constructed by the Corps of Engineers. The selected design values are presented in table A-2 below.

Table A-2. Reservoir Design Values.

	In Situ Older Alluvium	Compacted Buttress Fill
Dry Unit Weight, (pcf)	120	120
Moist Unit Weight, (pcf)	130	130
Saturated Unit Weight, (pcf)	140	140
Drained Angle of Internal Friction, (deg)	45	40
Permeability, (fpd)	10	0.1

SLOPE STABILITY

6-05 The stability of the basin slopes was analyzed in general accordance with EM 1110-2-1902, "Stability of Earth and Rockfill Dams," except for the rapid drawdown condition which was analyzed using a one-step, effective stress analysis. The soils design values used for this analysis are presented in table A-2.

6-06 Stability analyses were performed assuming-profiles that have been graded to a stable 1V on 1.5H slope above elevation 260 feet with a 1V on 2H buttress fill constructed by the Corps of Engineers below elevation 260 feet. As shown in figures A-3 and A-4 the minimum safety factors for the static, seismic, and rapid drawdown conditions in the flood control zone are 1.5, 1.0, and 1.0, respectively, indicating that the steepest allowable slope is 1V on 1.5H for intact alluvial materials. A seismic coefficient of 0.15, corresponding to seismic zone 4, was used for the seismic loading conditions. Stability analyses were performed on the entire gravel pit slope, including the buttress fill, for rapid drawdown, partial pool, and seismic conditions. As shown in figures A-3 and A-4, the safety factors for these conditions are 1.0, 2.2, and 1.3, respectively. A simplified displacement analysis was also conducted on the buttress fill slope. The analysis was based on a seismic event magnitude of 7.5 with a maximum bedrock acceleration of 0.5 g at the site. The analysis detrmined a maximum slope displacement of 3-1/2 feet.

Inlet and Outlet Structure Analysis

DESIGN VALUES

6-07 Design values for the proposed inlet and outlet structure are based on conservative interpretations of the field and laboratory data. Consideration was also given to values selected for similar materials on major Corps of Engineers projects. The values to be used for design are presented in table A-3.

BEARING AND SETTLEMENT

6-08 The allowable bearing pressure was determined in accordance with EM 1110-2-1903, Bearing Capacity of Soils, and is based the dimensions given for the inlet and outlet structure in the Phase I GDM. The strength and compressibility of the native materials are such that, settlement will be minimal and occur during construction.

Table A-3. Inlet and Outlet Structure Design Values.

Dry Unit Weight, (pcf)	120
Moist Unit Weight, (pcf)130	
Saturated Unit Weight, (pcf)	140
Angle of Internal Friction, (deg)	40
Coefficient of Active Earth Pressure	0.22
Equivalent Earth Fluid, (pcf)	30
Coefficient of Passive Earth Pressure	4.6
Equivalent Earth Fluid, (pcf)	645
Coefficient of At-Rest Earth Pressure	0.36
Equivalent Earth Fluid, (pcf)	50
Coefficient of Sliding Resistance,	0.4
Allowable Bearing Pressure,(psf)	10,000

VII. DESIGN APPLICATIONS

Channel Construction

EXCAVATION AND FILL

7-01 Where the existing channel invert is above the proposed invert elevation and where the existing side slopes are steeper than the required slope of 1V on 1.75H, soils will be excavated to the required grade. Excavation will be accomplished by conventional earthmoving equipment. Where the existing invert is below the proposed invert elevation and where the existing slopes are flatter than the required 1V on 1.75H compacted fill will be placed on the existing grade. The subgrades over which fill is to be placed will be proofrolled and scarified before placement of fill. All fill will be placed in 8-inch thick loose lifts and compacted to at least 90 percent of maximum density determined by ASTM D 1557.

RIPRAP

7-02 The channel slopes and invert will be protected by riprap. Riprap thicknesses will be 12, 15, 21, 24, and 36 inches. The riprap will require a filter system to prevent the slope and invert material from migrating. Filter stone, filter fabric, or filter fabric with a bedding layer may be used. The minimum specific gravity of riprap and filter materials will be 2.65. If filter stone is used, type I filter stone will be used for the 6-inch filter layers underlying the 12- and 15-inch riprap sections and type II filter stone will be used for the 9-inch filter layers underlying the 21-, 24-, and 36-inch riprap sections. Riprap and filter gradations are presented in table A-4. Filter fabric could be utilized with two different methods. One method would be to use filter fabric with a bedding layer to cushion the placement of the riprap. The bedding layer could consist of sandy streambed materials or an equivalent type of material. It is recommended to use filter type II for the 36-inch-thick riprap. Bedding layer thicknesses would be as required for the filter stone. Another method would be to use a heavier filter fabric without a bedding layer. This would require careful construction control. Filter fabric requirements are presented in table A-5.

Table A-4. Riprap and Filter Stone Gradations.

RIPRAP

Riprap Layer Thickness	Weight Individual Pieces (Pounds)	Approximate Average Dimension (Inches)	Percent Smaller by Weight
12-inch	125	12	100
	50	9	50-90
	25	7	20-50
	10	5	0-20
15-inch	250	15	100
	100	11	50-90
	50	9	20-50
	20	7	0-20
21-inch	675	21	100
	270	15	50-90
	135	13	20-50
	50	9	0-20
24-inch	1000	24	100
	400	18	50-90
	200	14	20-50
	80	10	0-20
36-inch	3400	36	100
	1400	26	50-90
	680	21	20-50
	250	15	0-20

FILTER STONE

Filter Type (Thickness)	Sieve Size	Percent Finer by Weight
Filter I (Coarse Aggregate) (6-inch)	2-1/2-inch	100
	2-inch	95-100
	1-inch	35-70
	1/2-inch	10-30
	No. 4	0-5
Filter II (Quarry Waste) (9-inch)	9-inch	100
	6-inch	90-100
	3-inch	65-80
	3/4-inch	25-40
	3/8-inch	0-10

Table A-5. Filter Fabric Requirements.

FILTER FABRIC WITH BEDDING LAYER

EOS (Equivalent Opening) Size	Tensile (lbs)	Elongation (%)	Puncture (lbs)	Tear (lbs)	Abrasion (lbs)
#50 to #70	100	15	40	30	25

FILTER FABRIC WITHOUT BEDDING LAYER

EOS (Equivalent Opening) Size	Tensile (lbs)	Elongation (%)	Puncture (lbs)	Tear (lbs)	Abrasion (lbs)
#50 to #70	200	15	80	30	55

Basin Construction

SLOPE CONSTRUCTION

7-03 As discussed in paragraph 6.2.2, the OCWD grading plan will include a buttress fill to elevation 230 feet and allows a project right of way setback of only 2 to 3 feet from a reposed, stable slope of 1V on 1.5H. The lineal extent of this 2- to 3-foot setback is about 2,500 feet along certain portions of the gravel pit perimeter adjacent to Bond and Hewes Avenues. If further setbacks within the right-of-way are desired for maintenance, access road, or recreational purposes, additional buttress fill will be required. To achieve a setback of 20 feet, the buttress fill must be raised to elevation 245 feet. A 30-foot setback will require a buttress fill to elevation 260 feet. Alluvial materials above the final buttress fill may be graded to 1V on 1.5H if desired, or they may be left intact with the understanding that standard project operating conditions will probably erode and eventually repose the alluvial materials to a 1V on 1.5H slope. The typical basin slope profile with a buttress fill constructed by the Corps of Engineers over the OCWD buttress to elevation 260 feet is presented in figures A-3 and A-4.

SLOPE PROTECTION

7-04 OCWD buttress slopes to receive fill will be stepped with benches 8 feet wide so that the weight of construction equipment will bear fully on lift layers being compacted. Fill will be placed in 8-inch thick loose lifts and compacted to at least 90 percent of maximum density determined by ASTM D 1557.

Inlet and Outlet Structure Construction

7-05 The foundation subgrade surface will be proofrolled to a smooth and uniform grade prior to any structural improvement. The backfill and fill materials will be selected from the required excavations. Materials with greater than 20 percent fines should not be used as backfill for retaining walls. The backfill will be placed in 8-inch loose lifts and compacted to not less than 90 percent of maximum density (ASTM D 1557). Fill materials will be placed on surfaces that have been cleared, proof-rolled, and scarified. Sloped ground or surfaces steeper than 4H on 1V will be flattened or stepped to an appropriate width so that the compaction equipment will bear fully on the fill layer. This fill will be compacted to not less than 95 percent of maximum density (ASTM D 1557).

VIII. CONCRETE MATERIALS

General

8-01 This section discusses the availability and suitability of concrete materials. The scope of this section is in accordance with the requirements of EM 1110-2-2000, Standard Practice for Concrete, dated 5 September 1985.

Concrete Requirements

8-02 It is estimated that approximately 7,100 cubic yards of concrete will be used for construction of the outlet structure and outlet channel. Twenty-eight day compressive strengths would be 4,000 psi for the box culvert and 3,000 psi for other construction.

Aggregate Sources

GENERAL

8-03 The following paragraphs summarize the potential sources of concrete aggregates available for the project. The material sources listed are representative of those currently used by local producers and have provided satisfactory service for concrete structures built in the area.

BLUE DIAMOND MATERIALS

8-04 This producer of concrete aggregate is located on an alluvial sand and gravel deposit along Santiago Creek. Blue Diamond has been at this location for 12 years and expects to be in production there for a minimum of 8 more. The plant produces 1-1/2-inch aggregate, 3/8 inch pea gravel, and washed concrete sand. Additionally the plant produces 3/4, 1/2, and 3/8 inch crushed rock as well as some boulders of up to 3-foot diameter. The plant has an annual output of approximately one million tons and is located approximately 2 miles downstream of the project.

FOSTER SAND AND GRAVEL

8-05 Foster Sand and Gravel is located along Temescal Wash near Corona, California and consists of an alluvial sand deposit. Foster has been at this location since 1972 and expects to be in production there for a minimum of 25 more years. The plant produces chiefly sand for fine aggregate although about 15 percent of its output consists of 1 inch aggregate and 3/8 inch pea gravel. The plant has an annual output of approximately one million tons and is location 35 miles from the project. Located in the immediate vicinity of Foster are several other producers of sand for use in concrete including R.J. Noble, Chandler, Concrete Products, Inc., and C.L. Pharris.

OWL ROCK

8-06 The Owl Rock Plant in Rialto has been located along Lytle Creek since 1955 and expects to be in production there for a minimum of 80 more years. The site consists of an alluvial deposit and produces 1-1/2 inches and 1 inch aggregate, 3/8 inch pea gravel, and washed concrete sand. The plant has an annual output of almost two million tons and is located approximately 45 miles from the project. While this source is not located in the immediate vicinity of the project area it is included here because it supplies aggregate to many ready mix firms which are in the project area.

TRANSIT MIXED CONCRETE

8-07 Transit Mixed Concrete mines a deposit along the San Gabriel River in Azusa, California which is alluvial in nature. Transit Mixed has been at this location for over 40 years and expects to be in production there for a minimum of 15 more years. The plant produces 1-1/2 inches and 1 inch aggregate, 3/8 inch pea gravel, and washed concrete sand and has an annual output of over three million tons. It is located approximately 35 miles from the project. Located in the immediate vicinity of Transit Mixed for several other aggregate producers including Blue Diamond Materials and Cal Mat. These producers also provide concrete aggregates to ready mix suppliers within the project area.

Cementitious Materials

CEMENT SOURCES

8-08 There are a relatively wide variety of cement producers in and near the Los Angeles basin which are capable of supplying cements certified by the Corps of Engineers ongoing cement certification program. Among these plants are the California Portland Cement Company plant at Colton, the Kaiser Cement Company plant at Lucerne Valley, the Southwestern Cement Company at Victorville, and the Riverside Cement Company plant at Riverside. All of these plants are in the state of California. The following paragraphs summarize the types of cements which these plants produce. Table A-6 supplies prices of various cements from the sources specified, and table A-7 contains cost data on the shipping of cement.

8-09 The California Portland Cement Company plant at Colton, located approximately 40 miles from the project, produces Type II and III cements conforming to the requirements of ASTM C 150.

8-10 The Kaiser Cement Company plant in the Lucerne Valley, located approximately 100 miles from the project, produces Type II cement conforming to the requirements of ASTM C 150. This plant also produces a blended cement conforming to the requirements of ASTM C 595, Type IP.

8-11 The Riverside Cement Company plant at Riverside, California, located approximately 32 miles from the project, produces Type II cement conforming to the requirements of ASTM C 150.

8-12 The Southwest Cement Company plant of Victorville, California, located approximately 80 miles from the project produces Type II and V cements conforming to the requirements of ASTM C 150.

Table A-6. Cement Prices in Dollars Per Ton.
(FOB Plant, December 1987)

Cement Plant and Location	Cement Type IP	II	III	V
California Portland, Colton	-	73.00	78.0	-
Kaiser, Lucerne Valley	73.00	60.00	-	-
Southwestern, Victorville	-	64.00	-	80.30
Riverside Cement, Riverside	-	63.00	-	-

Table A-7. Cement Shipping Prices in Dollars Per Ton.
(December 1987)

Distance (Miles)	Cost	Distance (Miles)	Cost	Distance (Miles)	Cost
3 - 5	3.142	30 - 35	4.480	70 - 80	7.828
5 - 10	3.296	35 - 40	5.200	80 - 90	8.446
10 - 15	3.450	40 - 45	5.922	90 - 100	9.012
15 - 20	3.760	45 - 50	6.386	100 - 110	9.682
20 - 25	3.966	50 - 60	6.902	110 - 120	10.300
25 - 30	4.224	60 - 70	7.314	120 - 130	11.072

POZZOLAN SOURCES

8-13 ETL 1110-1-127, dated 17 August 1984, requires the Federal government to allow the use of flyash in concrete construction except in those cases where its use can be proven to be undesirable. The local practice of the ready-mix concrete industry is to use flyashes as pozzolanic admixtures in concrete. The reasons for this is the reduction of heat of hydration, reduction in cost due to the price of flyashes in comparison to the price of cement, increased workability at lower water contents, and the reduction in the alkali-aggregate reaction. The practice of local agencies is to specify Type F flyash generally conforming to the requirements of ASTM C 618.

8-14 The closest local producer, the Western Ash Company, supplies flyash, conforming to the requirements of ASTM C 618, Type F, from a plant at Page, Arizona, approximately 555 miles from the project.

Admixtures

8-15 A wide variety of admixtures are regularly used by ready-mix concrete suppliers in the project area. These include: air entraining agents, accelerators, retarders, water reducers and high range water reducers. The relatively common methods anticipated for construction of the structures described should not require any speciality admixtures other than those recommended in the section: Recommendations.

Water

8-16 Water of sufficient quantity and suitability quality for the production of concrete will be available from local municipal water systems.

Curing Compounds

8-17 A wide variety of curing compounds are available for use from the aggregate suppliers to the local ready-mix concrete industry. Curing compounds will be specified in accordance with project requirements and ASTM C 309.

Transit Mixed Concrete

8-18 Commercial ready mixed concrete plants are located within competitive hauling distances. As of December 1987 the approximate cost of a cubic yard of concrete in the project area is $60.

Recommendations

AGGREGATES

8-19 Aggregates suitable for the production of concrete are available from the sources previously discussed. These sources are capable of supplying sufficient amounts of aggregates to meet the needs of this project. The nominal maximum size coarse aggregate would be 1-1/2 inches except 3/4 inch nominal maximum size coarse aggregate would be used when the minimum clear spacing between reinforcing is less than 2-1/4 inches. All aggregates used shall conform to the requirements of ASTM C 33.

CEMENTS

8-20 The following cements and requirements will be specified: cement would be Type II, low alkali (0.6 percent maximum), conforming to the requirements of ASTM C 150; and blended cements would conform to the requirements of ASTM C 595, Type IP.

POZZOLANS

8-21 The only pozzolanic materials generally in use locally are Type F flyashes conforming to the requirements of ASTM C 618. Specifications will call for flyashes conforming to the requirements of ASTM C 618, Type F, with the loss in ignition limited to 6 percent.

ADMIXTURES

8-22 Construction of the structures described above involve relatively simple construction procedures. The necessity for sophisticated admixtures is not anticipated. However, calcium chloride will not be permitted to be added for reinforced concrete because of the deleterious effect it may create by accelerating the corrosion of the reinforcing steel and concrete (ACI 201). The following types of admixtures will be specified in all construction.

Air Entraining Admixtures

8-23 If air entrained admixtures are used, they would conform to the requirements of ASTM C 260.

Accelerating Admixtures

8-24 Accelerating admixtures will conform to the requirements of ASTM C 494, Type C, except that no calcium chloride will be allowed in reinforced concrete.

Retarding Admixtures

8-25 Retarding admixtures will conform to the requirements of ASTM C 494, Type B or D.

Water Reducing Admixtures

8-26 Water reducing admixtures will conform to the requirements of ASTM C 494, Type A or D.

MIX PROPORTIONING

8-27 All materials used should be so proportioned as to produce a well graded mixture of high density and maximum workability, with a specified 28-day compressive strength of 3,000 or 4,000 psi. The water-cement ratio would be limited to 0.45. Slump in the range of 1 to 3 inches is recommended for workability.

IX. STONE SOURCES

9-01 Slope protection materials for the Santiago Creek channel improvements would be available from nearby commercial rock quarries. Local quarries which have produced suitable stone within the past 5 years for Corps of Engineers' construction projects are listed in table A-8. All these sources are within 30 miles of the upstream limits of the project. The Corona group of quarries (Corona-Pacific, Harlow, and 3M) would be the closest sources to the project. Stone could also be obtained from the more distant Atkinson, Declezville and Stringfellow operations in the Jurupa Mountains near Riverside.

Table A-8. Rock Quarry Locations.

Quarry	Nearest City	Minimum Distance to Site (mi)
Atkinson	Riverside	27
Corona-Pacific	Corona	18
Declezville	South Fontana	27
Harlow	Corona	18
Stringfellow	Riverside	27
3M	Corona	18

9-02 Results of recent quality compliance tests conducted by SPD laboratory on stone samples from the quarries listed in table A-8 are summarized in table A-9. In addition, the most recent Corps of Engineers project associated with each quarry source is shown. Although the quarries listed in table A-8 have provided suitable stone for Corps projects in the past, restrictions were placed on recent usage of stone from the Harlow Quarry near Corona. Stone from this source was accepted for use only as grouted stone in the Warm Creek-Santa Ana River

Confluence project because of the breakdown which occurred during the June 1985 wetting and drying test. Material from Harlow Quarry has also demonstrated an unsatisfactory service record on the existing Lower Santa Ana River levees between Weir Canyon Road and Katella Avenue because of its tendency to breakdown along incipient fractures. This fact might preclude or restrict the use of stone from Harlow Quarry on the Santiago Creek project. Despite a high abrasion loss shown for the Declezville Quarry, stone from this quarry has previously been accepted for use on Corps projects based on proven satisfactory service records. Stone from Declezville was placed in the San Pedro Breakwater, completed in 1912, and has shown no appreciable deterioration since that time.

9-03 Suitable stone may be available from additional quarries in the Riverside-Corona area or from other locations, but information on these potential sources is not included in table A-9, due to lack of either recent test data or service records on Corps projects. Although the majority of the sources have produced acceptable stone in the past, it cannot be assumed that they continue to do so. Therefore, any stone source considered for use as slope protection will require further field inspection and evaluation, and may require additional quality compliance testing prior to stone placement.

Table A-9. Santiago Creek.

POTENTIAL STONE SOURCES - QUALITY COMPLIANCE TEST RESULTS

Rock Quarry	Rock Type	Specific Gravity Bulk (SSD)	Specific Gravity Apparent	Absorption (%)	Sulfate Soundness (% loss)	Abrasion (% loss)	Date Tested[1]	Remarks[2]
Atkinson	Monzonite/ Monzodiorite	2.76	2.77	0.1	2.0	25.2	6/85	Sepulveda Basin
Corona-Pacific	Tonalite	2.67	2.68	0.3	0.5	14.1	4/88	San Pedro Brkwtr
Declezville	Granodiorite	2.77	2.79	0.3	2.3	46.5	11/83	Morro Bay North and South Breakwaters
Harlow	Andesite	2.66	2.66	0.2	1.6	14.3	6/85	Warm Creek-Santa Ana River Confluence
Stringfellow	Granite	2.66	2.67	0.2	0.4	18.3	6/85	San Pedro Breakwater
3M	Andesite	2.69	2.70	0.4	0.5	10.0	9/83	Dana Point Breakwater

NOTES:
1. Only the most recent test results are shown for each stone source.
2. Rock from Harlow Quarry was only suitable for use as grouted stone on the Warm Creek-Santa Ana River Confluence project due to 50 percent failure during the wetting and drying test. The Declezville Quarry has provided suitable rock for Corps of Engineers projects based on service records.

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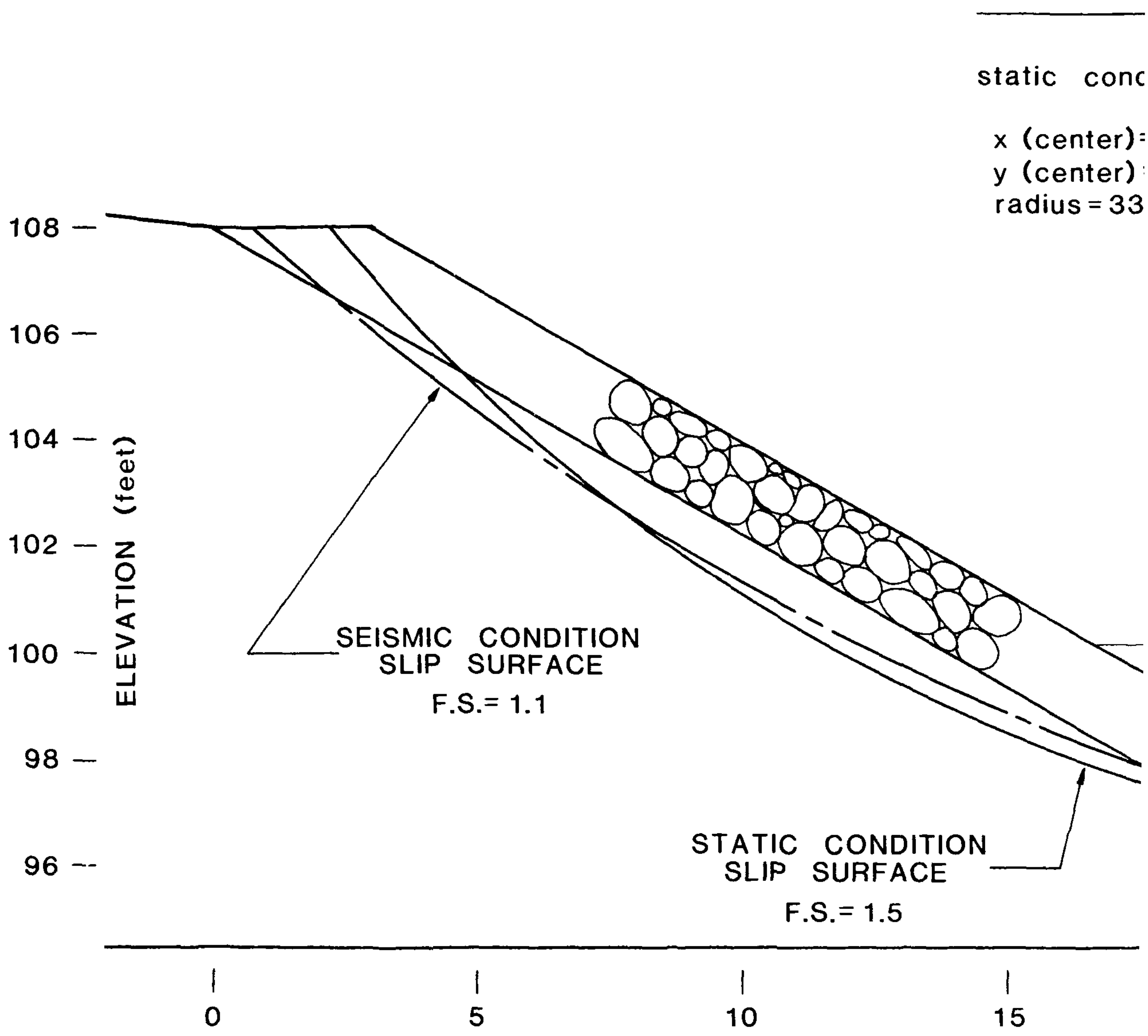


STATION 12+0

Scale: 1 inch=3 fe

CIRCLE DATA

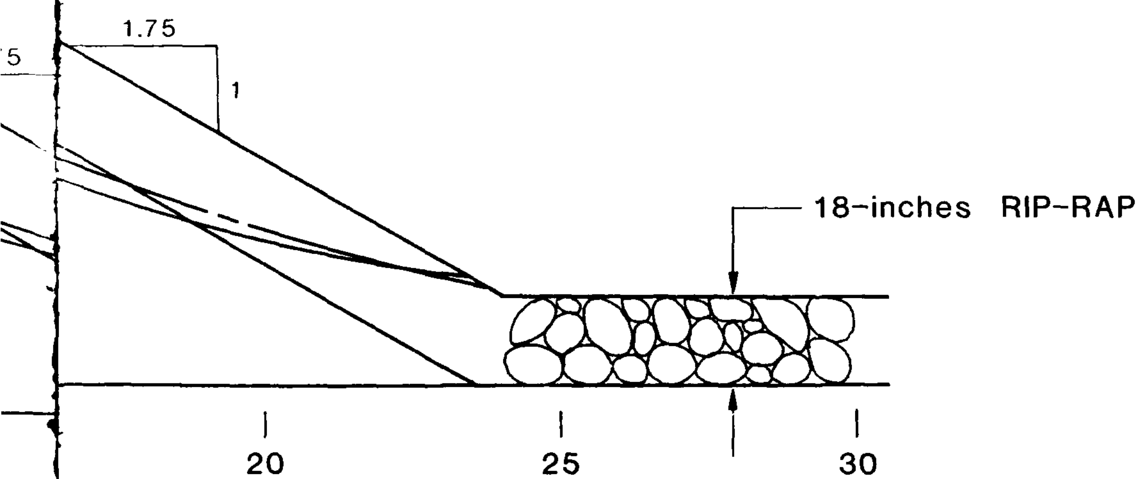
C

on:

7.5

29

condition:	seismic condition:
ter) = 27.5	x (center) = 34.5
ter) = 129.0	y (center) = 145.5
= 33.0	radius = 50.5



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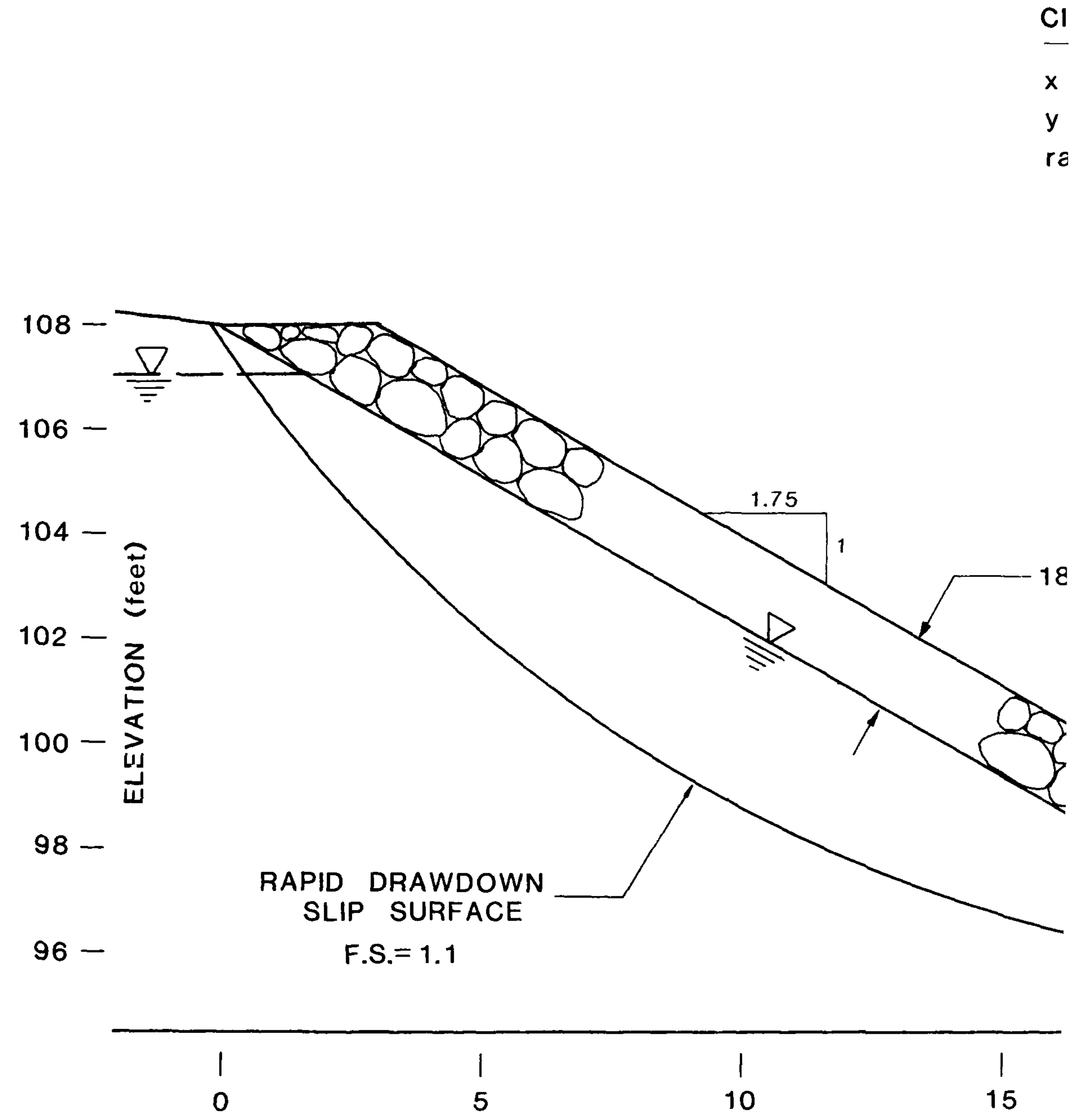
3 feet

SANTIAGO CREEK CHANNEL

SLOPE STABILITY ANALYSIS

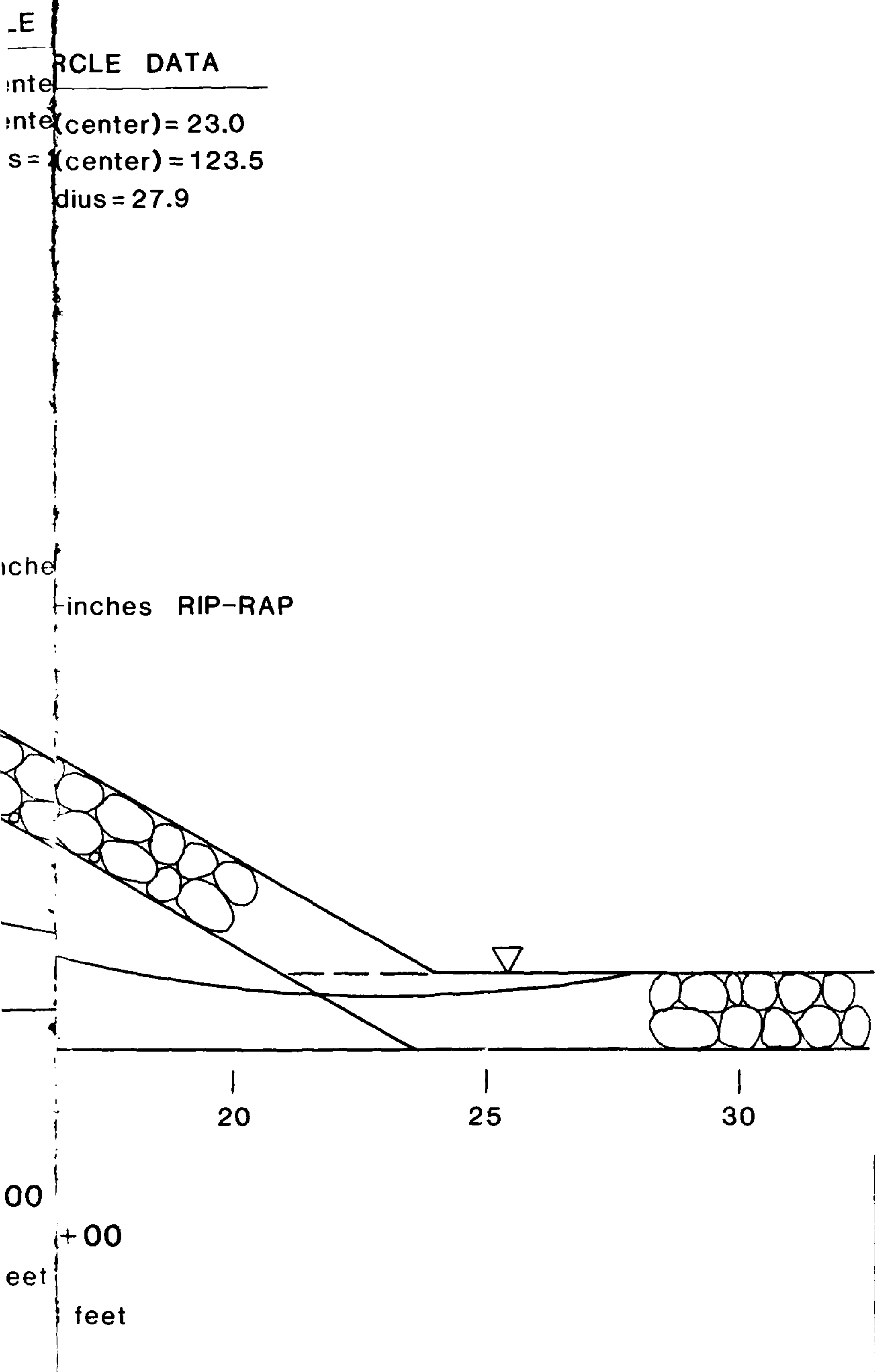
STATIC AND SEISMIC CONDITIONS

FIGURE A-1



STATION 1

Scale: 1 inch=



SANTIAGO CREEK CHANNEL

SLOPE STABILITY ANALYSIS

RAPID DRAWDOWN CONDITION

FIGURE A-2

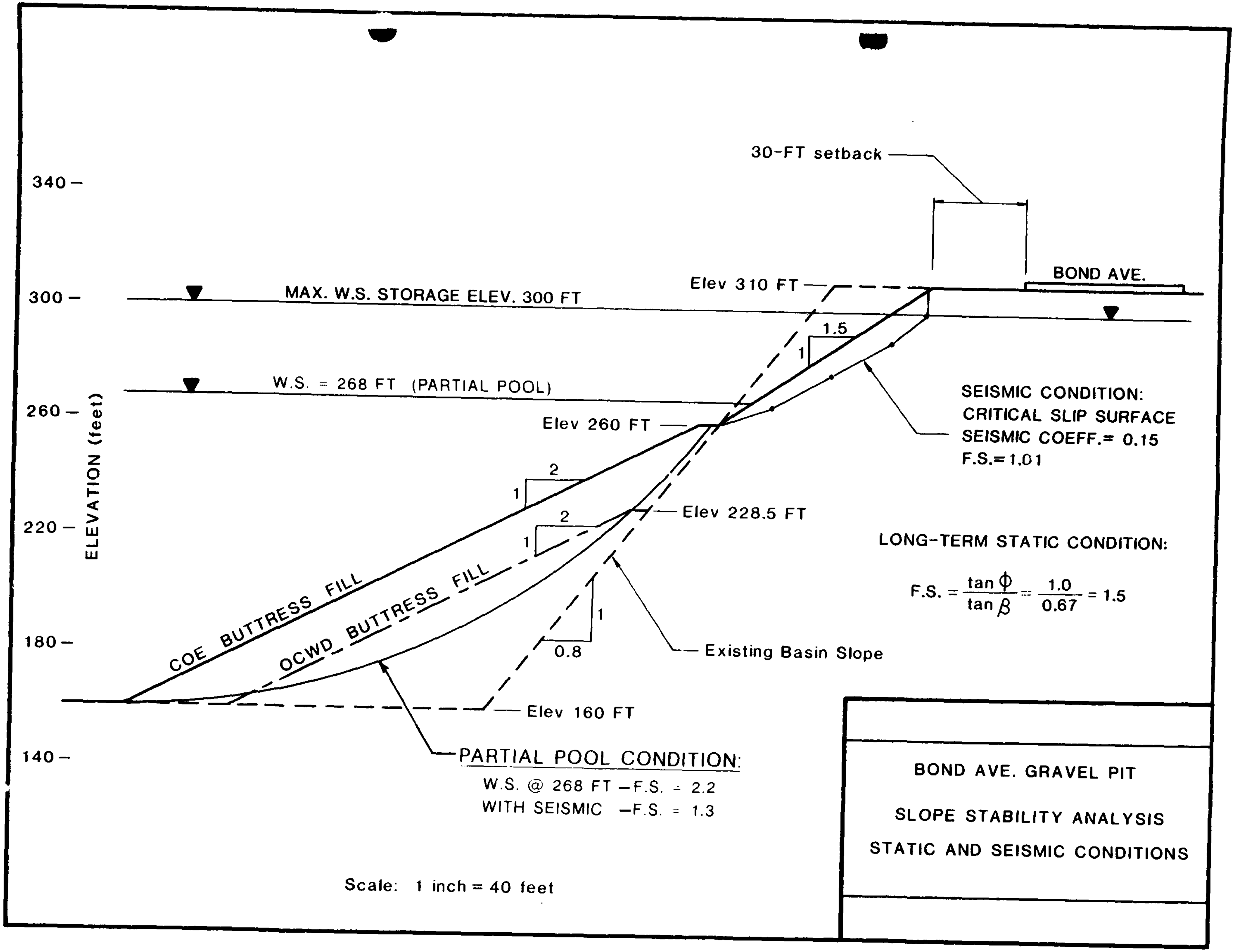
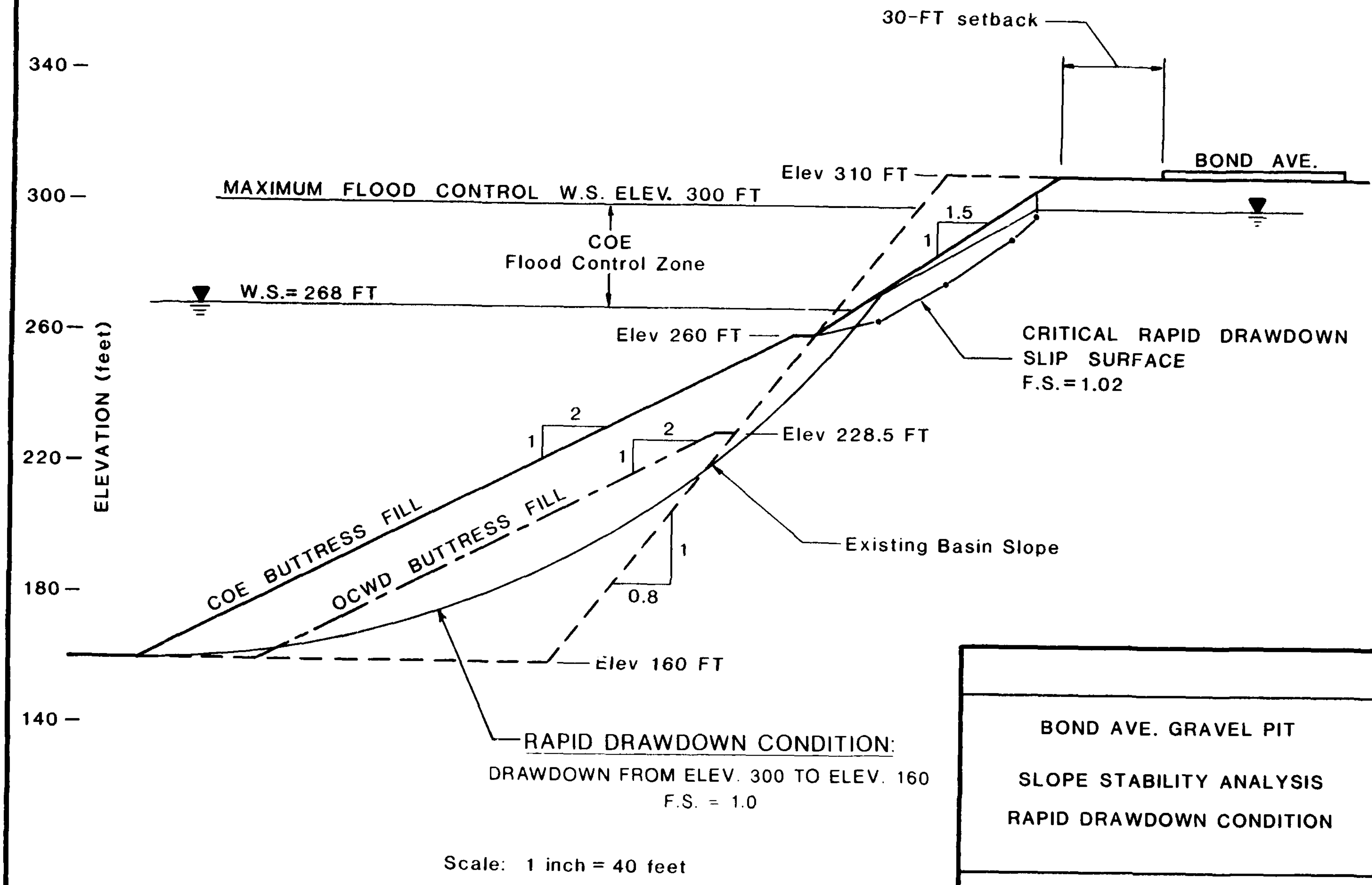

30-FT setback
BOND AVE.
Elev 310 FT
MAX. W.S. STORAGE ELEV. 300 FT
W.S. = 268 FT (PARTIAL POOL)
340
300
260
220
180
140
ELEVATION (feet)
1.5
1
Elev 260 FT
SEISMIC CONDITION:
CRITICAL SLIP SURFACE
SEISMIC COEFF.= 0.15
F.S.=1.01
2
1
Elev 228.5 FT
LONG-TERM STATIC CONDITION:
F.S. = $\frac{\tan \phi}{\tan \beta} = \frac{1.0}{0.67} = 1.5$
COE BUTTRESS FILL
OCWD BUTTRESS FILL
0.8
Existing Basin Slope
Elev 160 FT
PARTIAL POOL CONDITION:
W.S. @ 268 FT —F.S. = 2.2
WITH SEISMIC —F.S. = 1.3
Scale: 1 inch = 40 feet
BOND AVE. GRAVEL PIT
SLOPE STABILITY ANALYSIS
STATIC AND SEISMIC CONDITIONS

FIGURE A-3

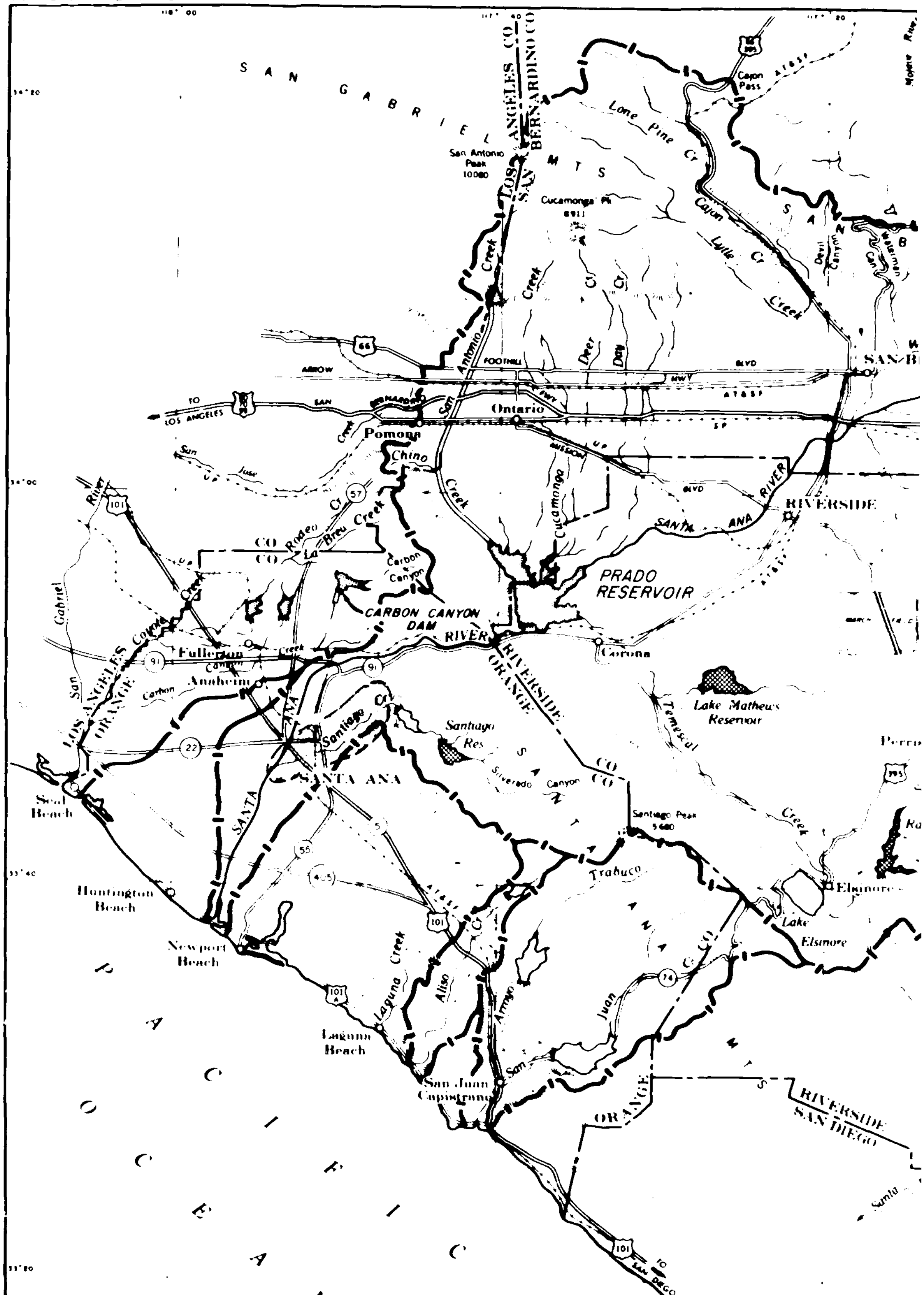


BOND AVE. GRAVEL PIT

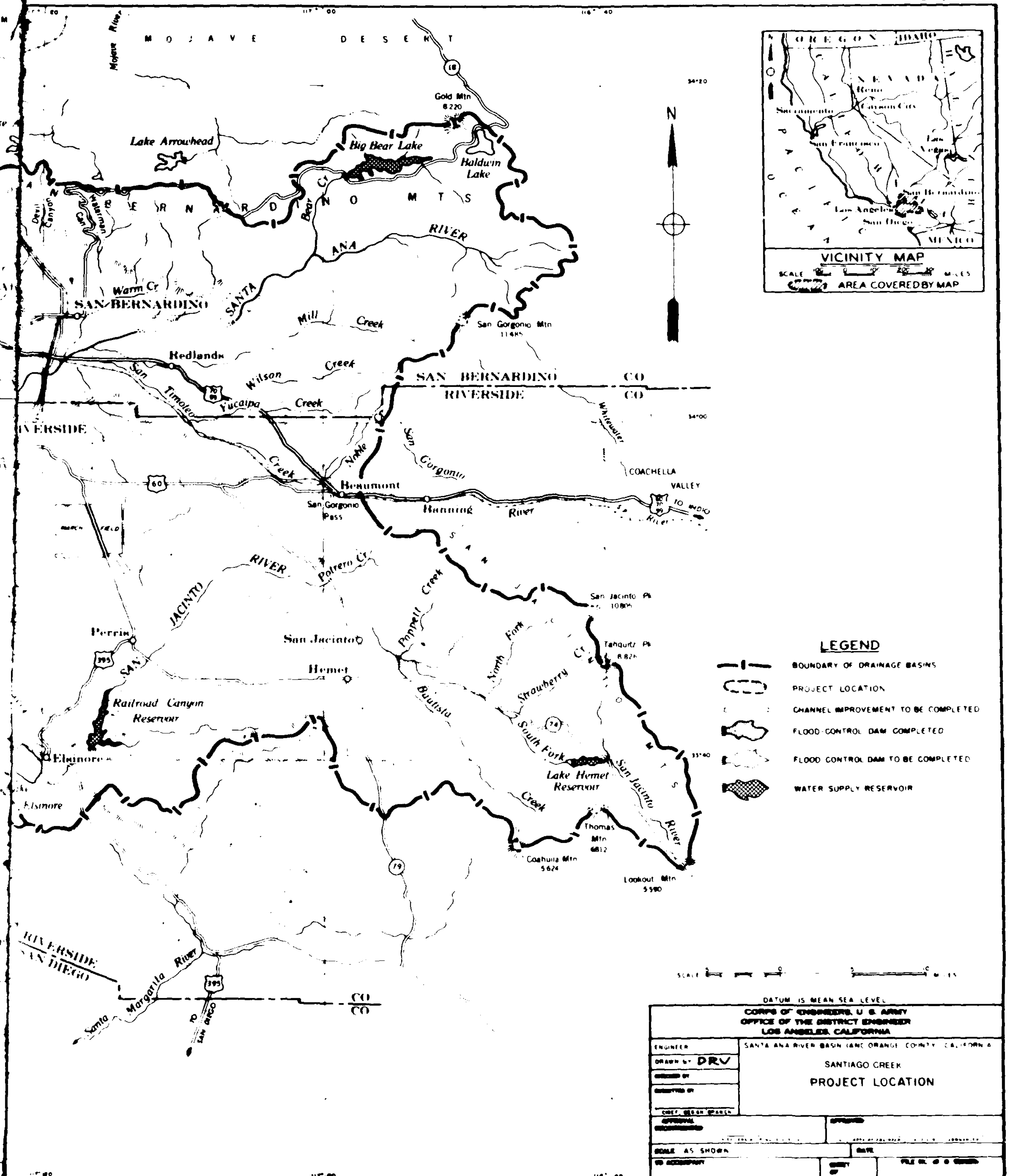
SLOPE STABILITY ANALYSIS

RAPID DRAWDOWN CONDITION

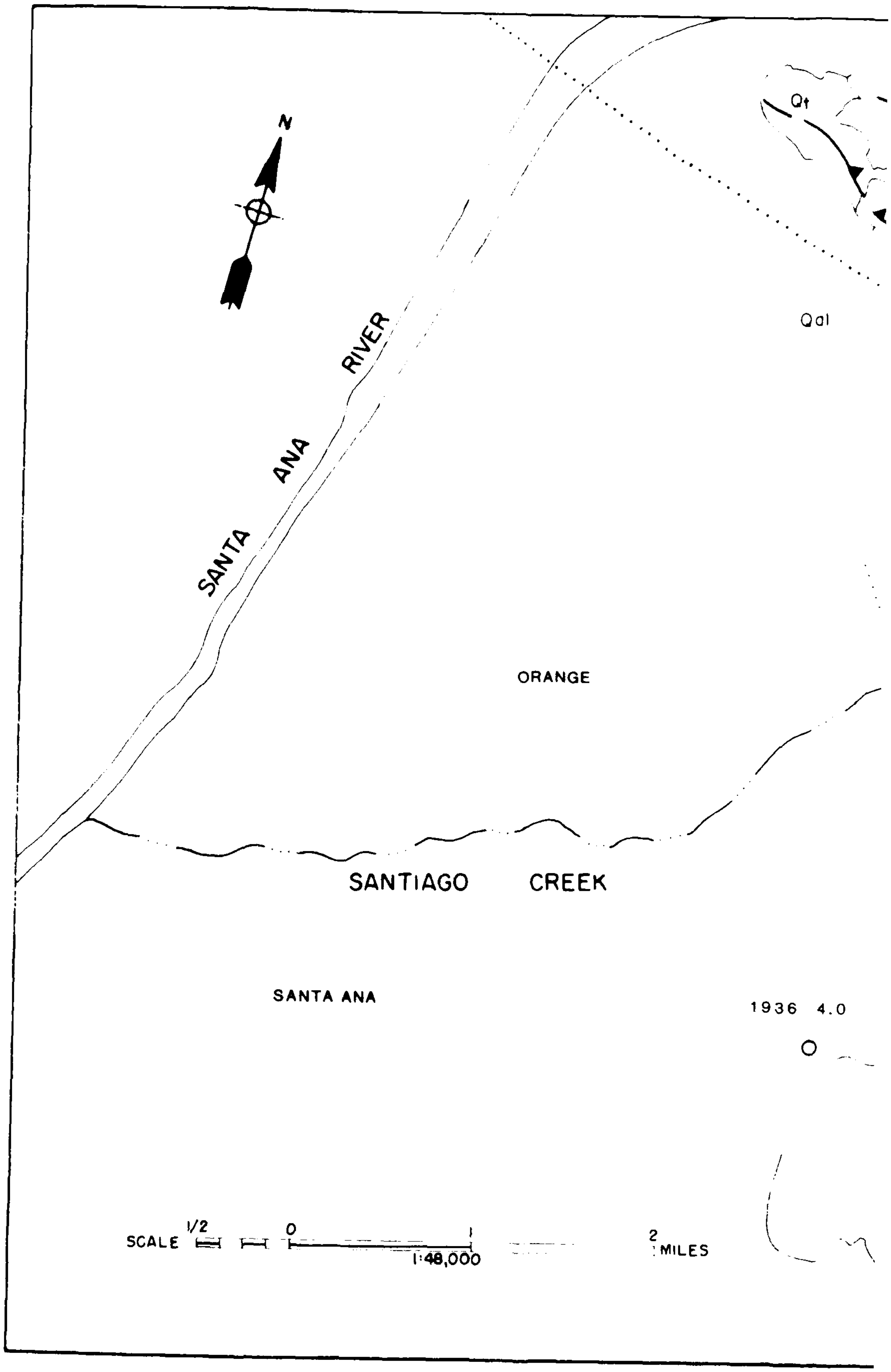
FIGURE A-4

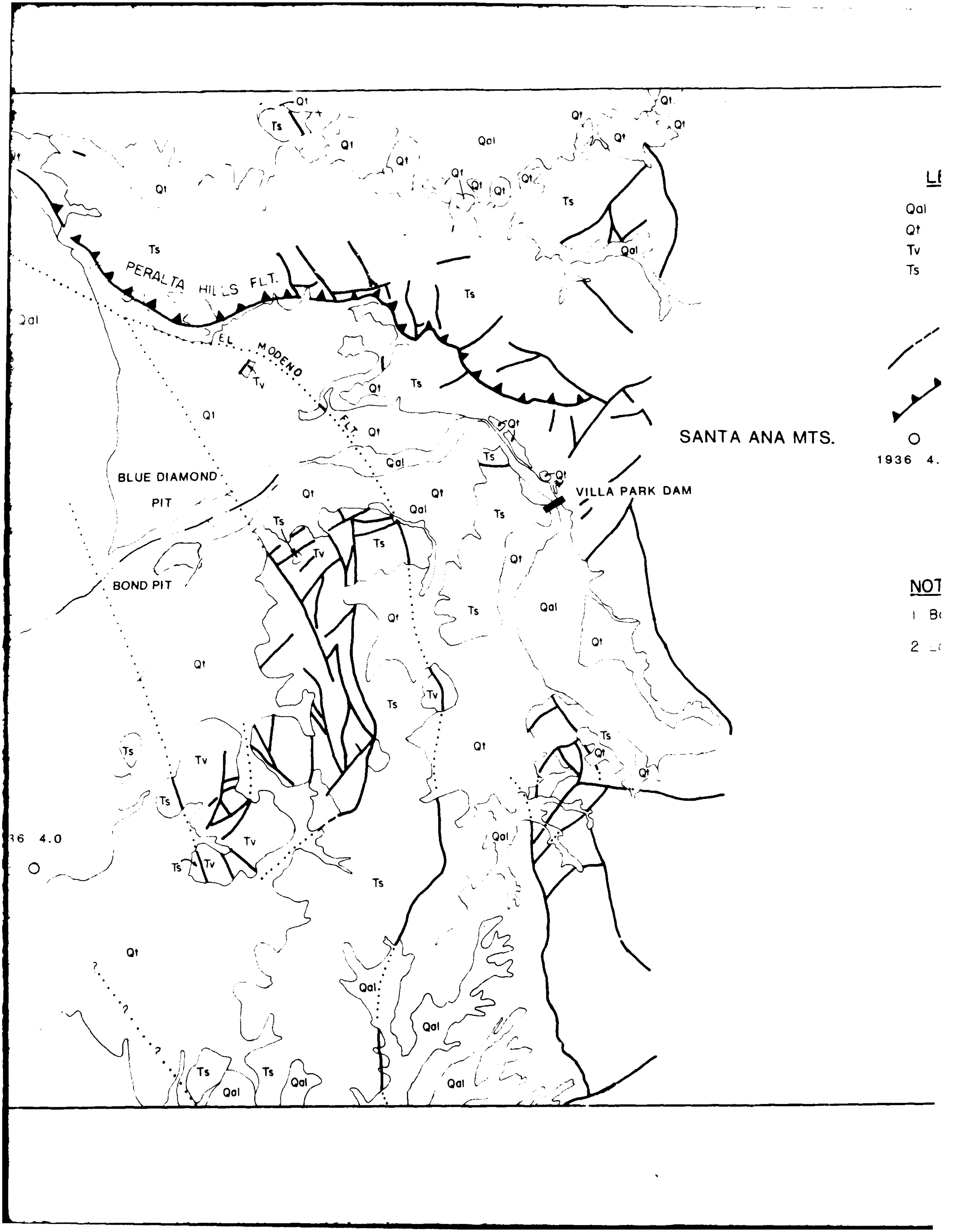

SAN GABRIEL MTS
LOS ANGELES CO.
SAN BERNARDINO CO.
San Antonio Peak 10080
Cucamonga Pk 8911
Lone Pine Cr
Cajon Pass
Cajon
Lytle Cr
Creek
Devil Canyon
Waterman Can
SAN B
FOOTHILL BLVD
ARROW HWY
TO LOS ANGELES
SAN BERNARDINO FWY
Ontario
Pomona
Chino
San Antonio Creek
Deer
Day
Cucamonga
MISSION BLVD
RIVERSIDE
SANTA ANA RIVER
PRADO RESERVOIR
Corona
San Jose
Rodeo Cr
La Brea Creek
Carbon Canyon
CARBON CANYON DAM
RIVER
Fullerton
Anaheim
Carbon
Coyote Creek
San Gabriel River
LOS ANGELES
ORANGE
RIVERSIDE
ORANGE
Lake Mathews Reservoir
Temescal
Santiago Res
Santiago Cr
Silverado Canyon
SANTA ANA
SANTA
Seal Beach
Huntington Beach
Newport Beach
Santiago Peak 5680
Trabuco
Creek
Elsinore
Lake Elsinore
Perris
Laguna Creek
Aliso
Arroyo
San Juan
Laguna Beach
San Juan Capistrano
RIVERSIDE
SAN DIEGO
ORANGE
CO
CO
PACIFIC OCEAN
TO SAN DIEGO
Santa

U. S. ARMY



MOJAVE DESERT
Mojave River
Gold Mtn 8220
Lake Arrowhead
Big Bear Lake
Baldwin Lake
Bear Cr
Devil Canyon
Waterman Canyon
SAN BERNARDINO MTS
SANTA ANA RIVER
Warm Cr
SAN BERNARDINO
Mill Creek
San Gorgonio Mtn 11485
Redlands
Wilson Creek
SAN BERNARDINO CO
RIVERSIDE CO
San Timoteo Creek
Yucaipa Creek
RIVERSIDE
Noble Cr
San Gorgonio
Whitewater
COACHELLA VALLEY
Beaumont
San Gorgonio Pass
Banning
River
TO INDIO
SAN JACINTO RIVER
Potrero Cr
Poppet Creek
San Jacinto Pk 10805
Perris
San Jacinto
Hemet
North Fork
Tahquitz Pk 8826
Strawberry Cr
Bautista
Railroad Canyon Reservoir
South Fork
Elsinore
Lake Hemet Reservoir
San Jacinto River
Creek
Thomas Mtn 6812
Coahuila Mtn 5624
Lookout Mtn 5590
RIVERSIDE
SAN DIEGO
Santa Margarita River
CO
CO
TO SAN DIEGO
VICINITY MAP
OREGON IDAHO
NEVADA
Reno
Carson City
Sacramento
San Francisco
Las Vegas
PACIFIC OCEAN
San Bernardino
Los Angeles
San Diego
MEXICO
AREA COVERED BY MAP
LEGEND
BOUNDARY OF DRAINAGE BASINS
PROJECT LOCATION
CHANNEL IMPROVEMENT TO BE COMPLETED
FLOOD CONTROL DAM COMPLETED
FLOOD CONTROL DAM TO BE COMPLETED
WATER SUPPLY RESERVOIR
DATUM IS MEAN SEA LEVEL
CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
SANTA ANA RIVER BASIN (AND ORANGE COUNTY) CALIFORNIA
SANTIAGO CREEK
PROJECT LOCATION
DRAWN BY DRV
SCALE AS SHOWN


N
Qt
Qal
SANTA ANA RIVER
ORANGE
SANTIAGO CREEK
SANTA ANA
1936 4.0
SCALE 1/2 0 1 2 MILES
1:48,000



PERALTA HILLS FLT.
EL MODENO FLT.
BLUE DIAMOND PIT
BOND PIT
SANTA ANA MTS.
VILLA PARK DAM
Qal
Qt
Tv
Ts
1936 4.
36 4.0
NOT
1
2

LEGEND

Qal	Recent alluvium and colluvium
Qt	Pleistocene terrace deposits
Tv	Tertiary volcanics, undifferentiated
Ts	Tertiary sedimentary formations, undifferentiated
	Contact between geologic units
?	Fault; dashed where approximately located, dotted where concealed; queried where conjectural
	Thrust fault, sawteeth on side of upper plate
O 1936 4.0	Earthquake epicenter, giving year of event and Richter magnitude

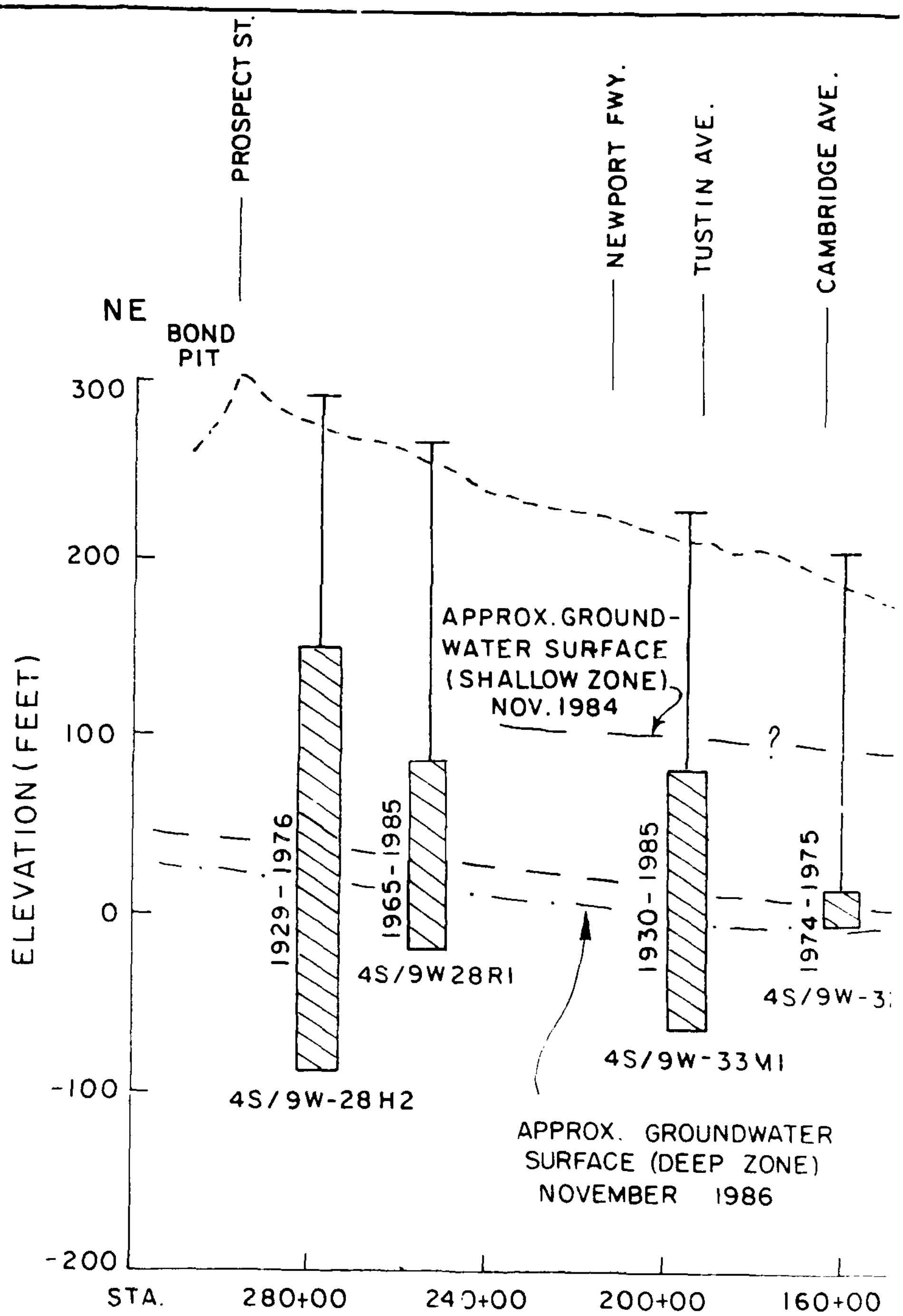
NOTES:

1. Base map and geology after Morton and Miller (1981).
2. Location of Peralta Hills fault from Bryant and Fife (1982)

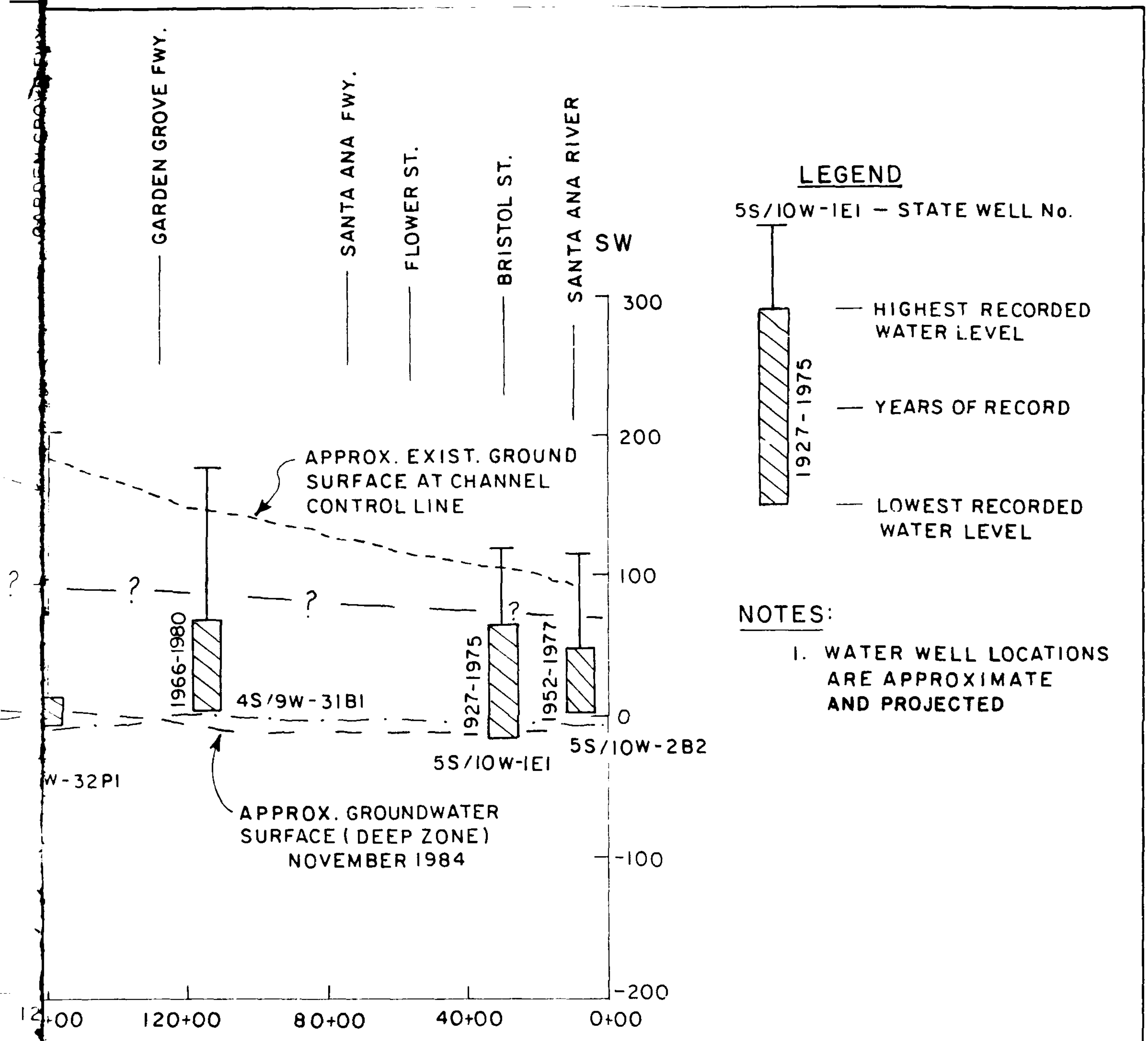
SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA R. MAIN STEM (INCL SANTIAGO CRK)

SANTIAGO CREEK
GENERAL SITE GEOLOGY
PLAN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



GROUNDWATER PROFILES A



ONGS ALONG SANTIAGO CREEK

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

RIZ

VE

1 IN = 4000 FT

HORIZ. SCALE 5000 0 5000

1 IN.= 100 FT.

VERT. SCALE 100 0 100

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCL SANTIAGO CRK)

SANTIAGO CREEK

GROUNDWATER PROFILES

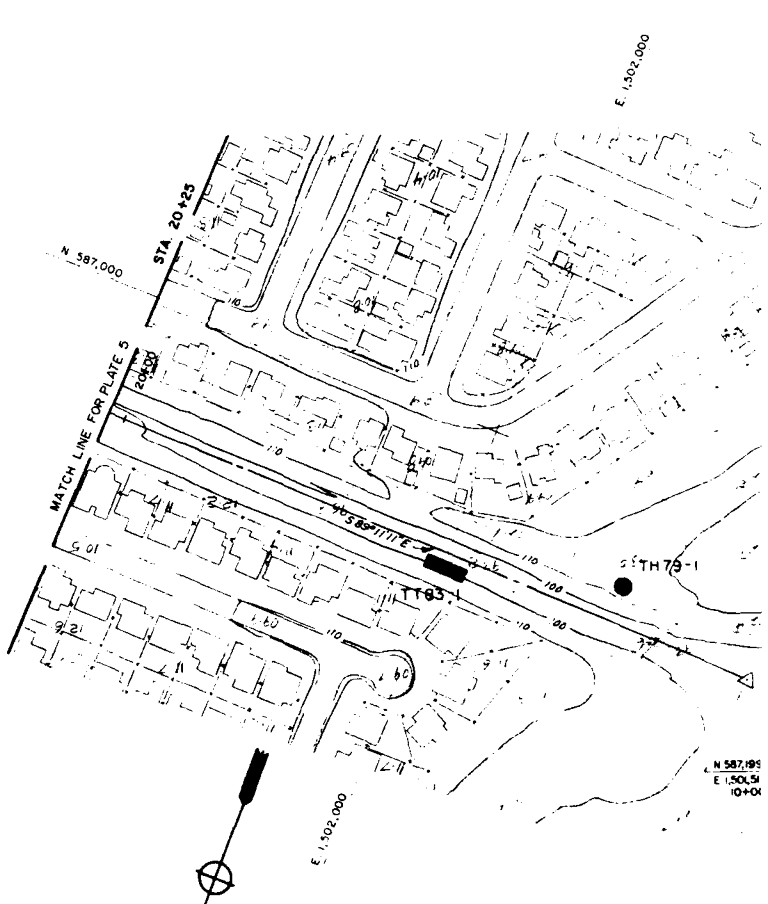
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

VALUE

TT83-1

DEPTH	LOG	LL	PI	-4	-200	DESCRIPTION
0.5'						SURFACE DEBRIS Cobbles to 12 inches
1.0'	GP			47	1	SANDY GRAVEL grey, moist, medium to coarse grain to 3 inches
2.0'	CL	38	16	100	86	CLAY brown, damp
7.0'	SP		NP	71	1	GRAVELLY SAND damp, loose, fine grained gravel
8.0'	CL	33	14	100	72	SANDY CLAY brown, moist
W10.0'	SP	19	2	100	29	SAND brown, saturated, medium to fine grained
12.0'	SP		NP	100	14	

DEPTH	LOG	MC	LL	PI	-4	-200
	SM	3		NP	76	19
9.0'	SM	12		NP	92	30
13.5'	SP-SM	6		NP	94	7
16.5'	CL	21	39	21	100	79
21.0'	SM	17		NP	100	49
25.5'	CL	21	32	14	100	82
W 28.5'	CL-ML	22	26	5	100	50
30.0'	SM	23		NP	100	36



PLAN

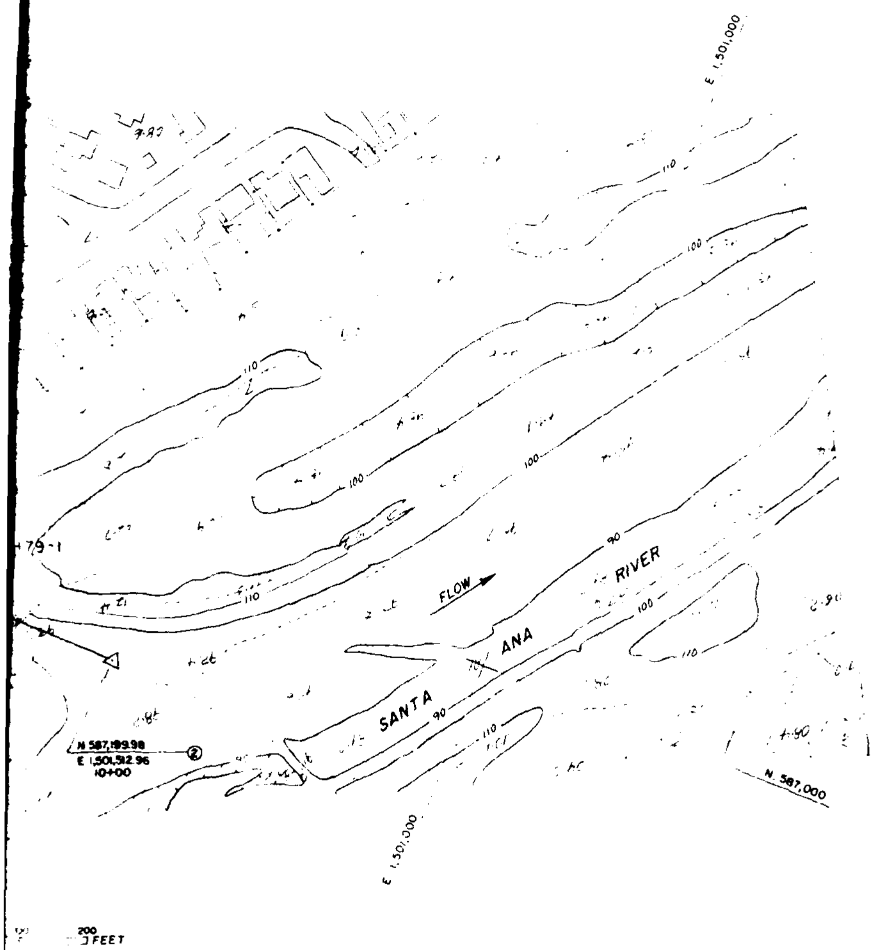
SCALE 100 0 100 200 FEET

TH79-1

PI	-4	-200	N	DESCRIPTION
NP	76	19	R, 24	*SILTY GRAVELLY SAND* brown, damp, medium dense, some pea-size gravel
NP	92	30	7	*SILTY SAND* brown, moist, loose, chunks of clay, angular gravel to 1 inch, cohesion.
NP	94	7	14, 18	*SAND/SILTY SAND* light brown, damp, medium dense, angular gravel to 1 inch, no cohesion
21	100	79	27	*SANDY CLAY* brown, moist, very stiff, gravel to 1 inch, cohesion
NP	100	49	20, 18	*SILTY SAND* tan, moist, medium dense, gravel to 1/2 inch, cohesion
14	100	82	9	*SANDY CLAY* dark brown, moist to damp, stiff, rounded gravel to 1 inch, cohesion
5	100	50	17	*SANDY CLAY/SANDY SILT* gray brown, wet, cohesion HIT GROUND WATER AT 28'-0"
NP	100	36		*SILTY SAND* gray brown, wet, cohesion

NOTES:

1. SEE PLATE 15 FOR LEGEND AND SOIL CLASSIFICATION
2. TEST HOLES DRILLED ON TOP OF BANK IN 1979
   TEST TRENCHES EXCAVATED IN INVERT IN 1983



SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)
SANTIAGO CREEK
LOCATIONS AND LOGS OF EXPLORATION STA. 10+00 TO STA. 20+25
U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT

VALU

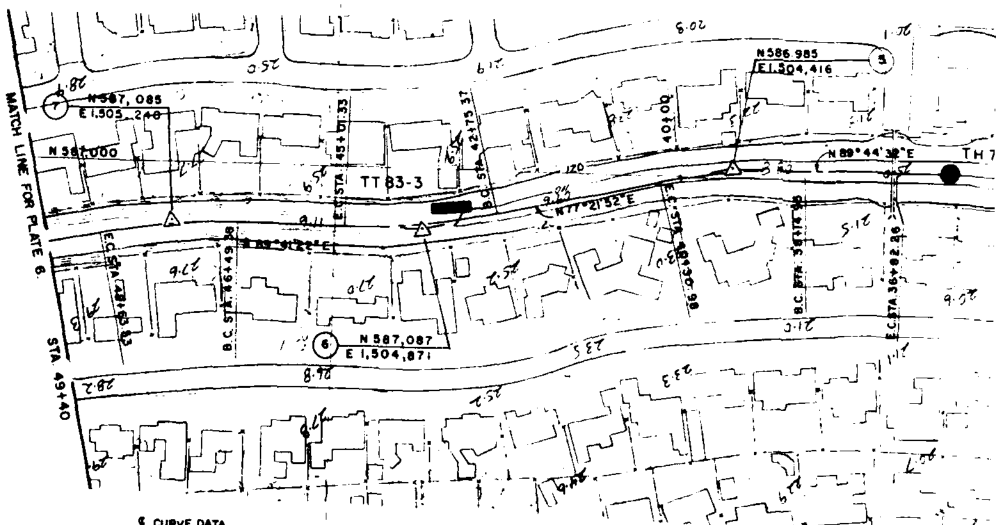
TT83-3

DEPTH	LOG	LL	PI	-4	-200	DESCRIPTION
0.5'						SURFACE DEBRIS: cobbles
3.0'	GW		NP	40	1	SANDY GRAVEL: brown, moist, coarse gravel to 1-1/2 inches, medium grained sand.
4.0'	CL	46	23	100	78	SANDY CLAY: brown, moist, stiff, clay nodules
6.0'	SP/SM		NP	96	7	SAND/SILTY SAND: brown, moist, medium to fine grained.
	CL	35	13	100	89	SANDY CLAY: brown, moist, stiff, clay nodules. CLAY: medium stiff, some platey fine grained particles.
15.0'		30	12	100	54	SANDY CLAY: fine grained sand.
15.5'	SP		NP	82	1	GRAVELLY SAND brown, moist to wet, medium to fine grained, few gravel to 1/2 inch.

DEPTH	LOG
3.0'	SP-SM
6.0'	SW-SM
10.5'	SC
15.0'	CL
19.5'	SM
25.5'	ML
30.0'	SM

℄ CURVE DATA
Δ=12°56'46"
R=1,000'
T=113.45'
L=225.95'

E 1,505,000



℄ CURVE DATA
Δ=12°16'13"
R=1,000'
T=107.48'
L=214.15'

E 1,505,000

℄ CURVE DATA
Δ=12°22'40"
R=1,000'
T=108.43'
L=216.03'

SC

ENGINEERING PAYS

TH79-2

	PI	-4	-200	N
			11	R
	NP	72	11	R
	NP	77	49	18
4	17	96	73	14
15	18	99		14
			50	17
	NP	100	63	18
	NP	100	67	5
	NP	100	22	10
	NP	9_	36	25
	NP	9_		

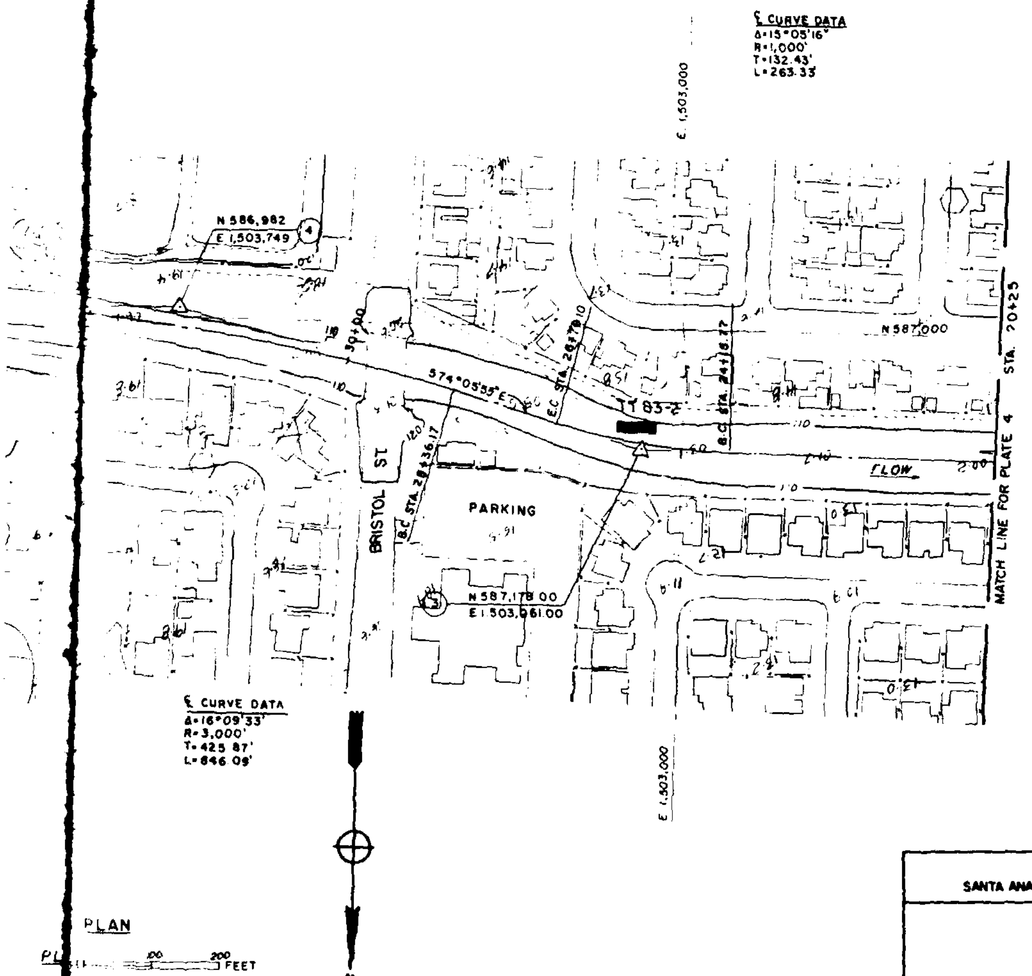
DESCRIPTION

- GRAVELLY SAND/SILTY GRAVELLY SAND: tan, dry subrounded gravel to 2 inches, no cohesion.
- GRAVELLY SAND/SILTY GRAVELLY SAND: light brown, dry to damp, subrounded gravel to 2 inches, no cohesion
- CLAYEY SAND: dark brown, wet, medium dense, subrounded pea gravel, cohesion.
- SANDY CLAY: dark brown, moist, stiff, very little gravel.
- SILTY SAND: brown, moist, medium dense, some subrounded gravel to 1 inch maximum (< 5%), some cohesion
- SANDY SILT: brown, moist, stiff, some gravel to 3 inches maximum, (may be caving).
- brown, moist to wet, medium consistency, large chunks.
- SILTY SAND: brown, wet, medium dense

TT83-2

DEPTH	LOG	LL	PI	-4	-200	DESCRIPTION
0.5'						SURFACE DEBRIS: cobbles, sand, organics, trash.
1.5'	GW		NP	28	0	SANDY GRAVEL: brown, moist, fine grained to 1 inch, medium to coarse sand.
2.0'	SP		NP	67	1	GRAVELLY SAND: grey, moist to wet, medium grained, fine grained gravel to 1/2 inch.
5.0'	SC/SM	27	6	62	13	SILTY GRAVELLY SAND/CLAYEY GRAVELLY SAND: dark grey, wet, fine grained gravel to 1-1/2 inch, organic smell, perched water at 2-1/2 feet.
	GW		NP	28	1	SANDY GRAVEL: brown, moist, loose, coarse grained to 1-1/2 inches,
11.0'			NP	36	2	fine grained to 3/4 inch, medium to fine grained sand
11.5'	CL	30	10	100	63	SANDY CLAY: light brown, moist, stiff, 2 to 4 inch intermittent lens.
12.0'	SC	24	9	100	47	CLAYEY SAND: brown, moist, fine grained sand.

NOTE:
SEE PLATE 15 FOR LEGEND AND SOIL CLASSIFICATION.



PLAN

0 100 200 FEET

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)
SANTIAGO CREEK
LOCATIONS AND LOGS OF EXPLORATION STA. 20+25 TO STA. 49+40
U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT

SAFETY PAYS

PLATE A-5

VA

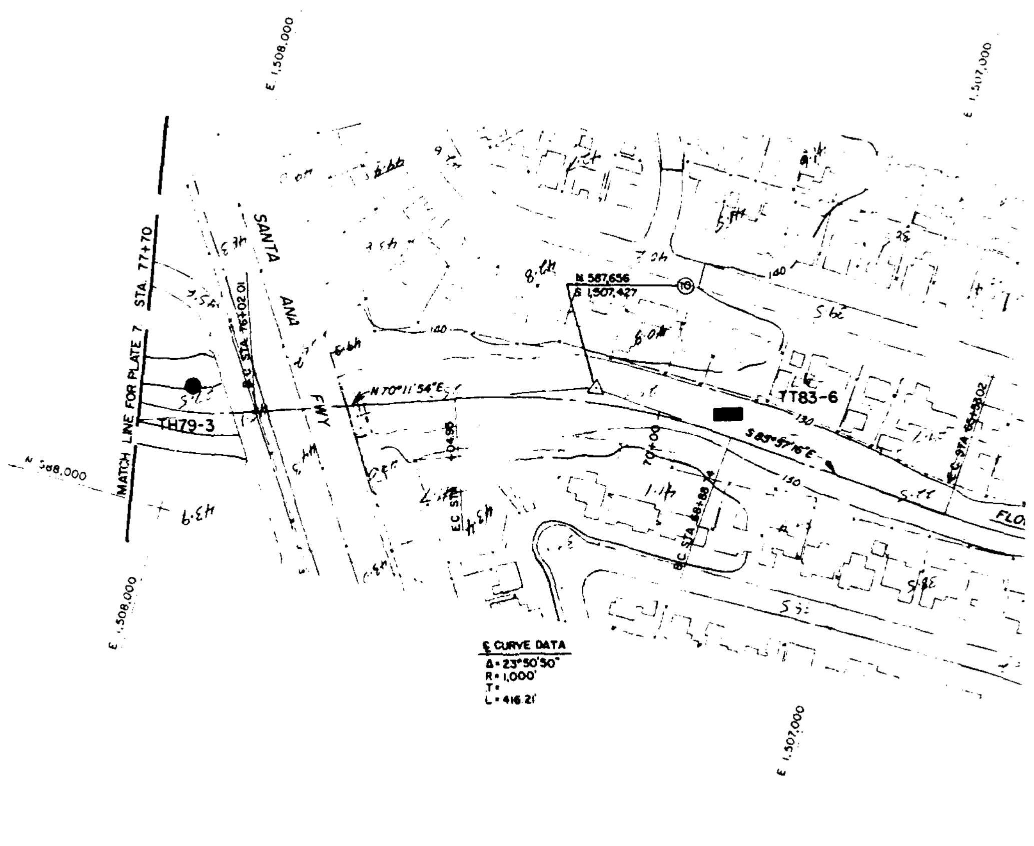
TH79-3

DEPTH	LOG	MC	LL	PI	-4	-200		DESCRIPTION
3.0	SM	1		NP	82	28	17	SILTY GRAVELLY SAND tan, dry, medium dense, pea gravel to 1 inch
9.0	GM	2		NP	56	15	R R	SILTY SANDY GRAVEL tan, dry, gravel up to 3 inches
10.5	SW/SM	2		NP	60	7		GRAVELLY SAND/SILTY GRAVELLY SAND brown, damp, medium dense, gravel to 1 inch.
	SM	10		NP	94	38	10 19	SILTY SAND brown, moist, pea gravel
19.5		9		NP	87	41	16	GRAVELLY SILTY SAND brown, moist, medium dense, subrounded gravel to 1 inch.
24.0	CL/ML	11	23	6	99	62	15 12	SANDY CLAY/SANDY SILT brown, moist, stiff, subrounded gravel to 1 inch
28.5	CL	11	24	9	98	54	12	SANDY CLAY brown, moist stiff, subrounded gravel to 1" max.
30.0	CL/ML	10	23	7	96	52	12	SANDY CLAY/SANDY SILT brown, moist, stiff, subrounded gravel to 1" max

TT83-6

DEPTH	LOG	LL	PI	-4	-200
0.5					
2.5	GW		NP	55	1
	GP		NP	18	2
4.0	SM	23	4	100	50
5.0	CL	29	9	100	73
6.0	SP		NP	100	2
7.5	SP/SM		NP	99	11
12.0	CL	27	9	98	54
15.0	CL/ML	24	6	99	62

SURFACE DEB
SANDY GRAVE
grained to
grey-brown,
SILTY SAND
dense fine g
SANDY CLAY
sand
SAND brown
grained, loo
SAND/SILTY
medium dens
creases wit
SANDY CLAY
grained san
SANDY SILT/
stiff fine



℄ CURVE DATA
Δ = 23°50'30"
R = 1,000'
T =
L = 416.21'

SCALE

DESCRIPTION

ACE DEBRIS: cobbles to 6 inches
Y GRAVEL light brown, moist, fine
ned to 2 inches, fine grained sand.
-brown, gravel to 1 1/2 inches.
Y SAND tan, damp to moist, medium
e fine grained.
Y CLAY tan, moist, stiff, fine grained
brown-grey, damp to moist, medium
ned, loose, some clay and silt lenses
/SILTY SAND light brown, damp to moist,
um dense, medium grained. Density in-
ses with depth.
Y CLAY tan, damp to moist, stiff, fine
ned sand
SILT/SANDY CLAY tan, da.. to moist,
fine grained sand.

TT83-5

DEPTH	LOG	LL	PI	-4	-200
0.5					
2.8	GP		NP	32	0
4.0	SP		NP	51	1
5.5	SC/SM	23	6	98	50
9.0	SP/SM		NP	96	6
11.0	ML	22	3	100	60
13.0	CL	28	10	100	65
15.5	SP		NP	84	3
16.0	CL	26	8	91	56

DESCRIPTION

SURFACE DEBRIS gravel trash
SANDY GRAVEL grey-brown, damp, loose, gravel to 2 inches, medium grained sand
GRAVELLY SAND brown, damp, medium grained, gravel to 1/2 inch
SILTY SAND/CLAYEY SAND brown, damp to moist, fine grained
SAND/SILTY SAND brown, damp, medium to fine grained
increase in grain size
SANDY CLAYEY SILT brown, moist, fine grained sand
SANDY CLAY brown, moist, very stiff
GRAVELLY SAND light brown, damp to moist, medium to fine grained, fine grained gravel
SANDY CLAY brown, moist, medium stiff, fine grained sand, few gravel to 3/4 inches

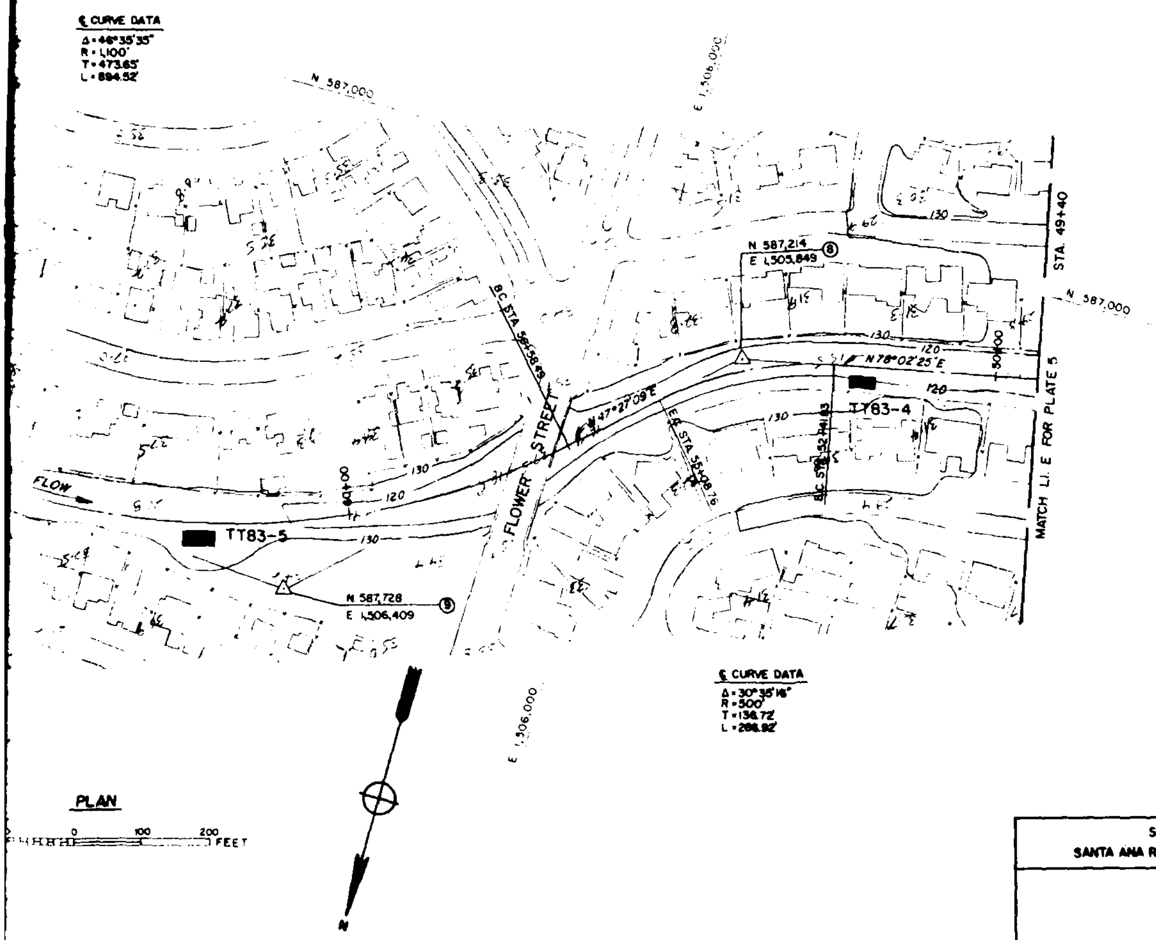
TT83-4

DEPTH	LOG	LL	PI	-4	-200
1.5	GP		NP	38	0
2.0	GC	38	20	41	14
3.5	GW		NP	24	0
6.0	SP		NP	73	1
8.0	CL	37	14	100	85
11.5	SM		NP	83	15
15.0	CL	33	13	100	73
16.0	SP/SM		NP	94	8

DESCRIPTION

SANDY GRAVEL grey-brown, dry to damp, gravel to 2 inches, medium grained sand
CLAYEY SANDY GRAVEL dark brown, moist, medium dense, slight organic smell
SANDY GRAVEL grey-brown, damp, coarse grained gravel to 3 inches, medium grained sand
GRAVELLY SAND brown, damp, coarse to medium grained, fine grained gravel to 3/4 inches.
CLAY brown, moist, medium stiff, platey fine particles
SILTY GRAVELLY SAND damp to moist, dense, fine gravel to 3/8 inch
SANDY CLAY brown, wet to saturated, medium stiff
SAND/SILTY SAND brown, wet, medium to fine grained.

NOTE:
SEE PLATE 15 FOR LEGEND AND SOIL CLASSIFICATION



SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK

LOCATIONS AND LOGS OF EXPLORATION
STA. 49+40 TO STA. 77+70

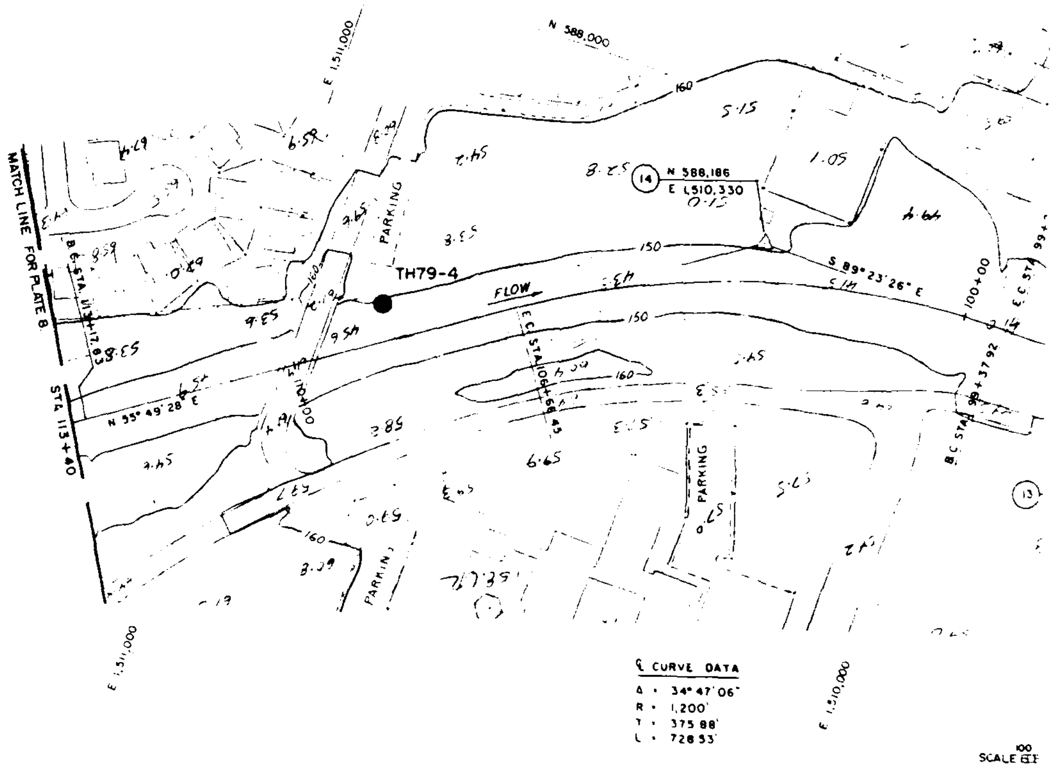
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE A-6

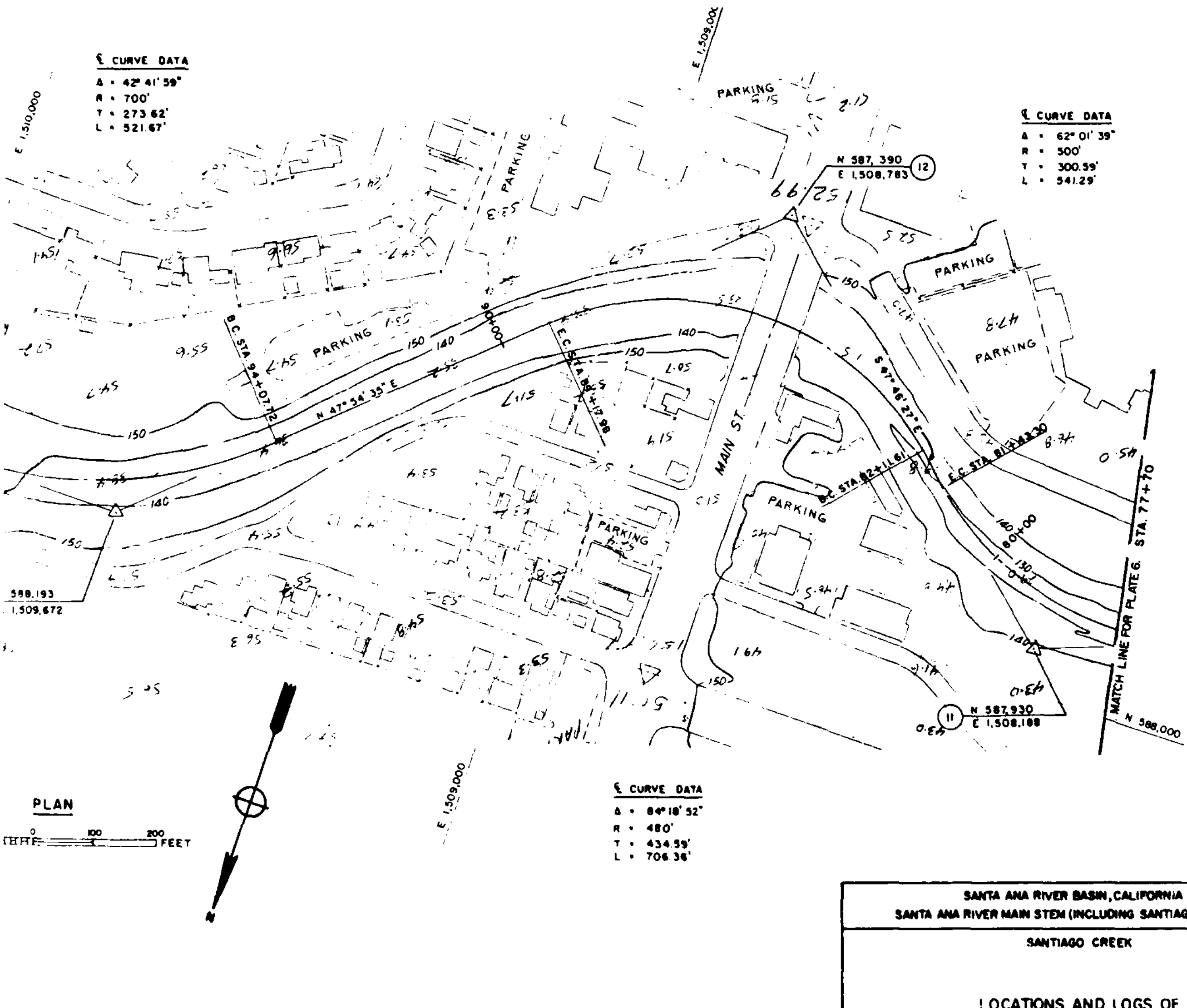
VAL

TH79-4

DEPTH	LOG	MC	LL	PI	-4	-200	N	
4.5	SC	4	24	7	77	28	R	GRAVELLY CLAYEY SAND brown, damp, cobbles to 4 inches, some cohesion.
7.5	SP-SM	2		NP	75	8	R	GRAVELLY SAND/SILTY GRAVELLY SAND brown, damp cobbles to 6 inches, no cohesion.
12.0	SM	3		NP	65	25	R, 9	GRAVELLY SILTY SAND light brown, damp, loose cobbles to 9 inches, some cohesion.
	CL-ML	13	26	5	100	66	10	SANDY CLAY/SANDY SILT light brown, moist, stiff, cohesion
21.0	CL-ML	14	23	6	99	56		brown, moist, gravel to 1½ inches, cohesion.
24.0	SM	8	22	7	74	26		GRAVELLY SILTY SAND brown, damp, cobbles to 7 inches, no cohesion
	SP-SM	3		NP	66	9		GRAVELLY SAND/SILTY GRAVELLY SAND brown, damp, cobbles to 6 inches, no cohesion.
28.5	SP-SM	3		NP	51	8		brown, damp, cobbles to 7 inches, no cohesion CAVING STARTED AT 29'-6".



NOTE:
SEE PLATE 15 FOR LEGEND AND SOIL CLASSIFICATION.



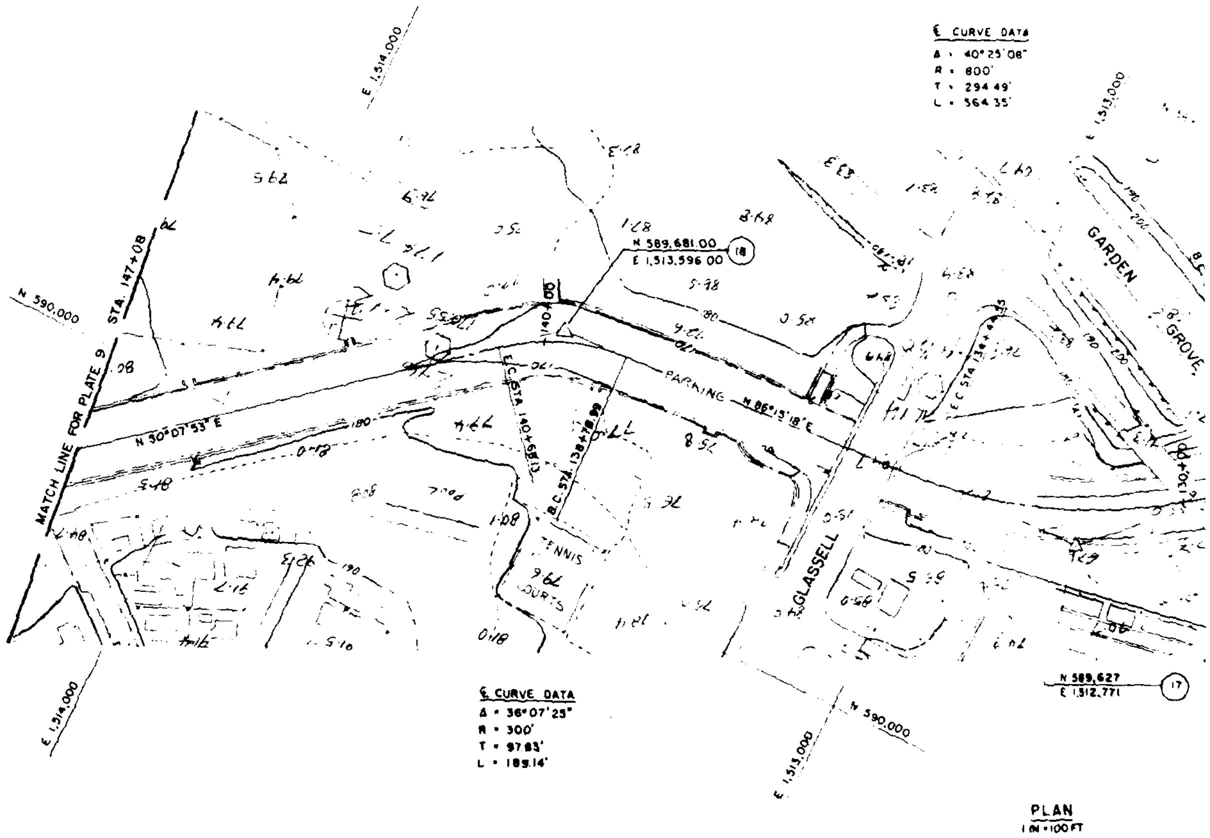
SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK

LOCATIONS AND LOGS OF EXPLORATION
STA. 77+70 TO STA. 113+40

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

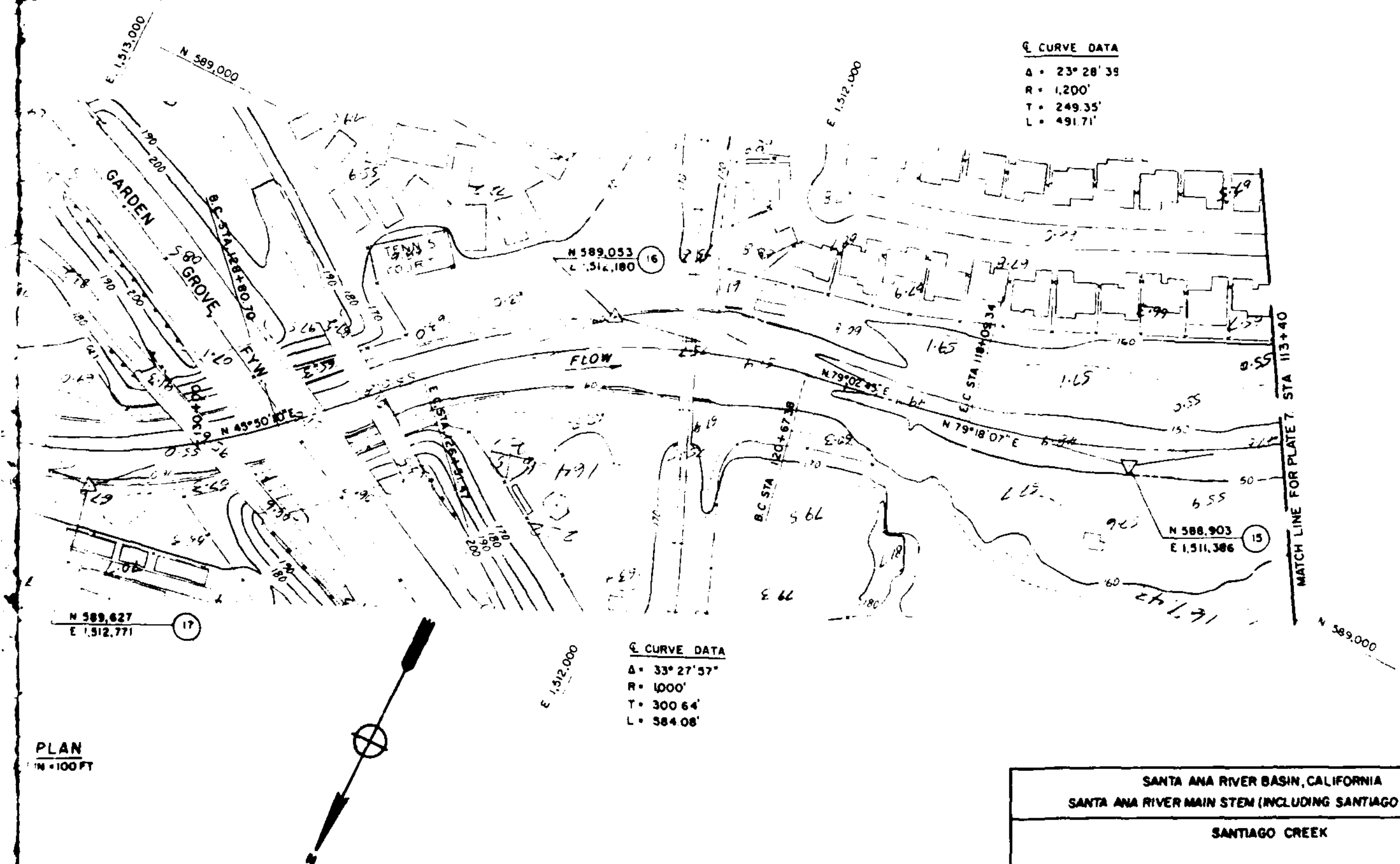
PLATE A-7


℄ CURVE DATA
Δ = 40°25'08"
R = 800'
T = 294.49'
L = 564.35'
MATCH LINE FOR PLATE 9 STA. 147+08
N 590,000
E 1,514,000
N 30°07'53" E
N 589,681.00
E 1,513,596.00
18
PARKING
N 86°13'18" E
E.C. STA. 140+58.13
B.C. STA. 138+78.99
TENNIS
COURTS
GLASSELL
GARDEN
GROVE
E 1,513,000
N 589,627
E 1,512,771
17
℄ CURVE DATA
Δ = 36°07'25"
R = 300'
T = 97.83'
L = 189.14'
PLAN
1 IN = 100 FT

VALUE ENGINEERING PAYS

NOTE:

THIS PLATE INCLUDED FOR CONTINUITY ONLY
NO EXPLORATION WAS CONDUCTED IN THIS AREA



PLAN
1 IN = 100 FT

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK

LOCATIONS AND LOGS OF EXPLORATION

STA. 113+40 TO STA. 147+08

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

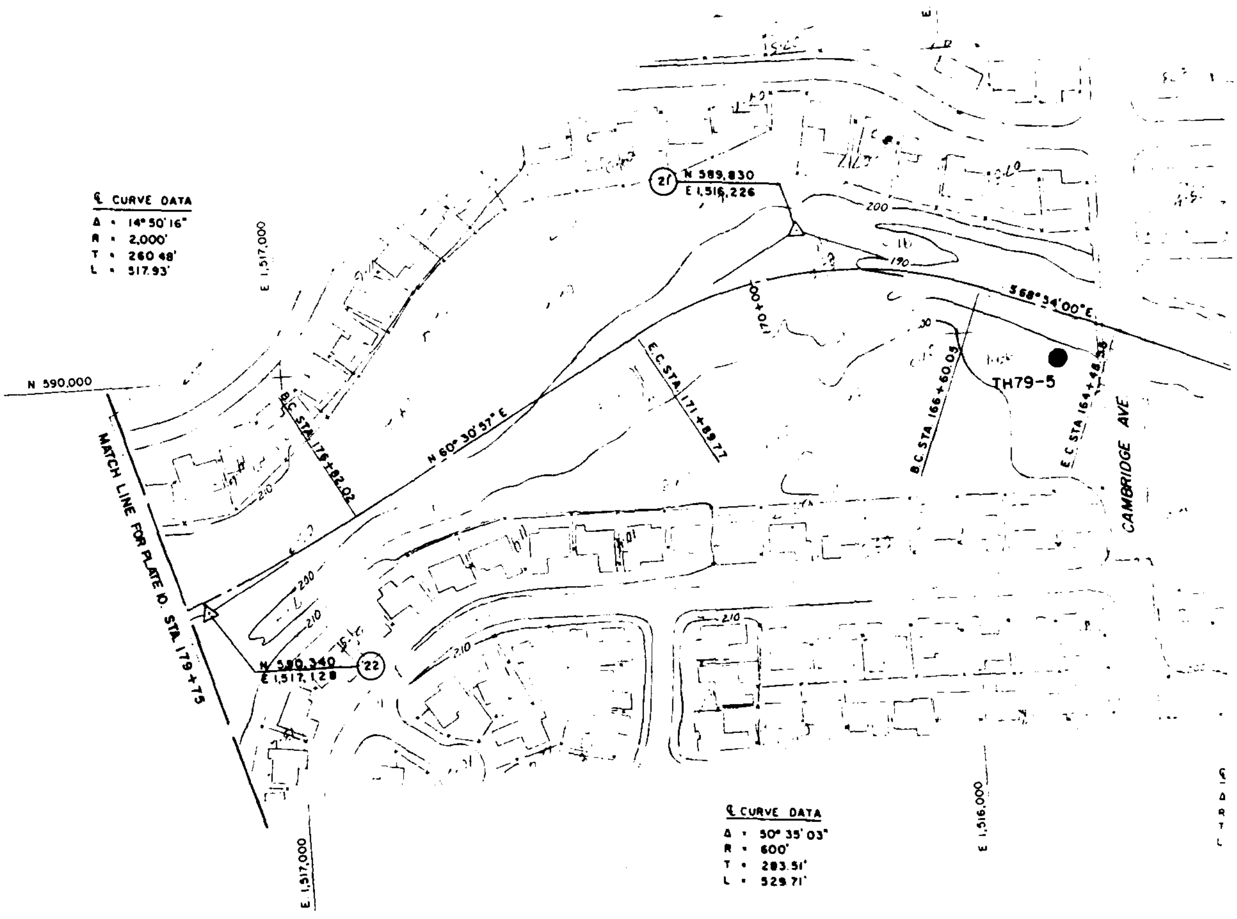
PLATE A-8

SAFETY PAYS

VALUE EN

TH79-5

DEPTH	LOG	MC	LL	PI	-4	-200	H	
4.5'	SC	5	23	6	76	26	R	GRAVE dry.
9.0'	SM	16		NP	100	33	R R	SILTY to 9
13.5'	SC	10	22	5	72	27	R	GRAVE cobb. cohe
16.5'	SM	6		NP	62	17	R	SILTY cobb
19.5	GW-GM	4		NP	52	10	R	SANDY damp.
20.0'	GW	2		NP	13	3		SANDY boulc

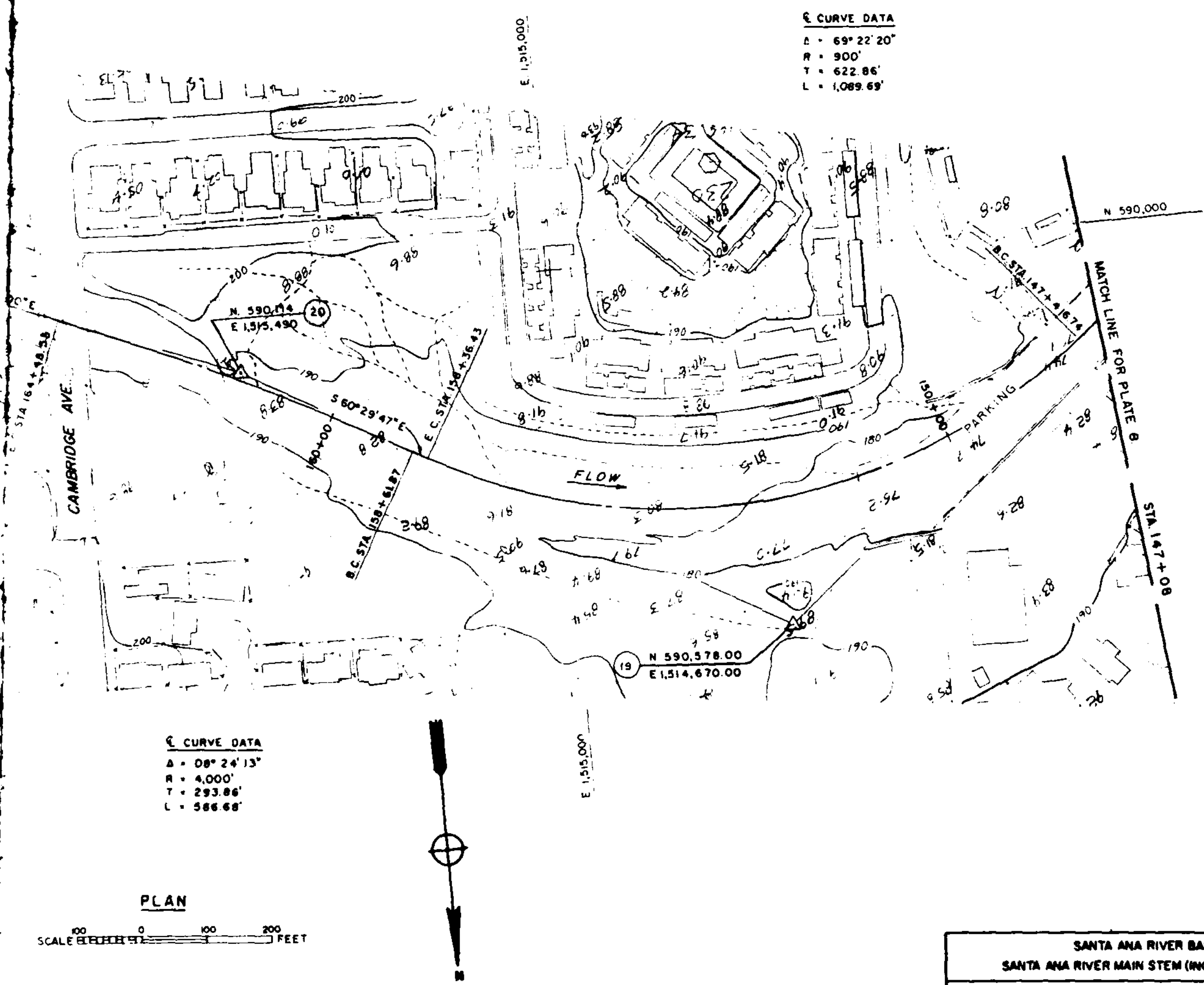


SAFE

TH79-5

PI	-4	-200	H	DESCRIPTION
6	76	26	R	GRAVELLY CLAYEY SAND brown, damp to dry, cobbles and boulders to 12 inches
NP	100	33	R R	SILTY SAND: gray brown, moist, cobbles to 9 inches.
5	72	27	R	GRAVELLY CLAYEY SAND. brown, damp, cobbles and boulders to 13 inches, some cohesion
NP	62	17	R	SILTY GRAVELLY SAND brown, damp, cobbles to 10 inches.
NP	52	10	R	SANDY GRAVEL/SILTY SANDY GRAVEL brown, damp, cobbles to 5 inches
NP	13	3		SANDY GRAVEL brown, damp, cobbles and boulders to 14 inches

NOTE:
SEE PLATE 15 FOR LEGEND AND SOIL CLASSIFICATION



PLAN

SCALE 100 0 100 200 FEET

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK

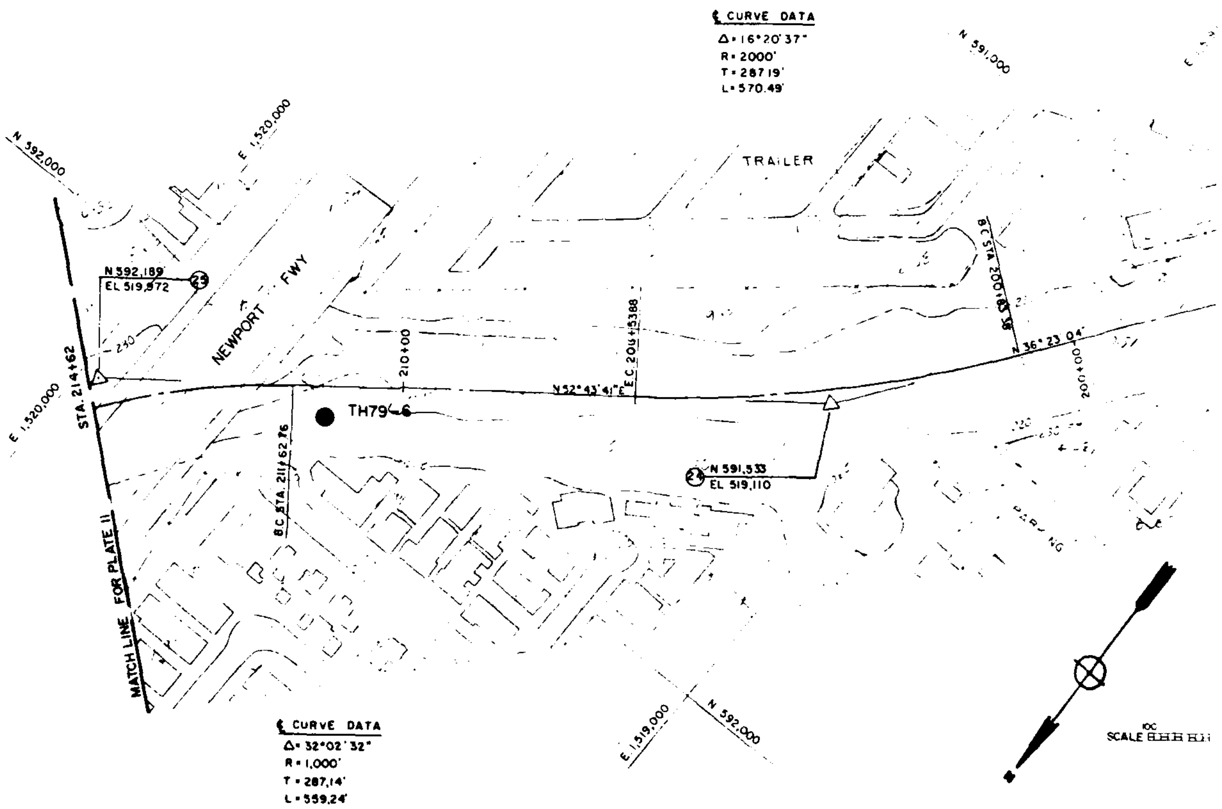
LOCATIONS AND LOGS OF EXPLORATION
STA. 147+08 TO STA. 179+75

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

VALUE EN

TH79-6

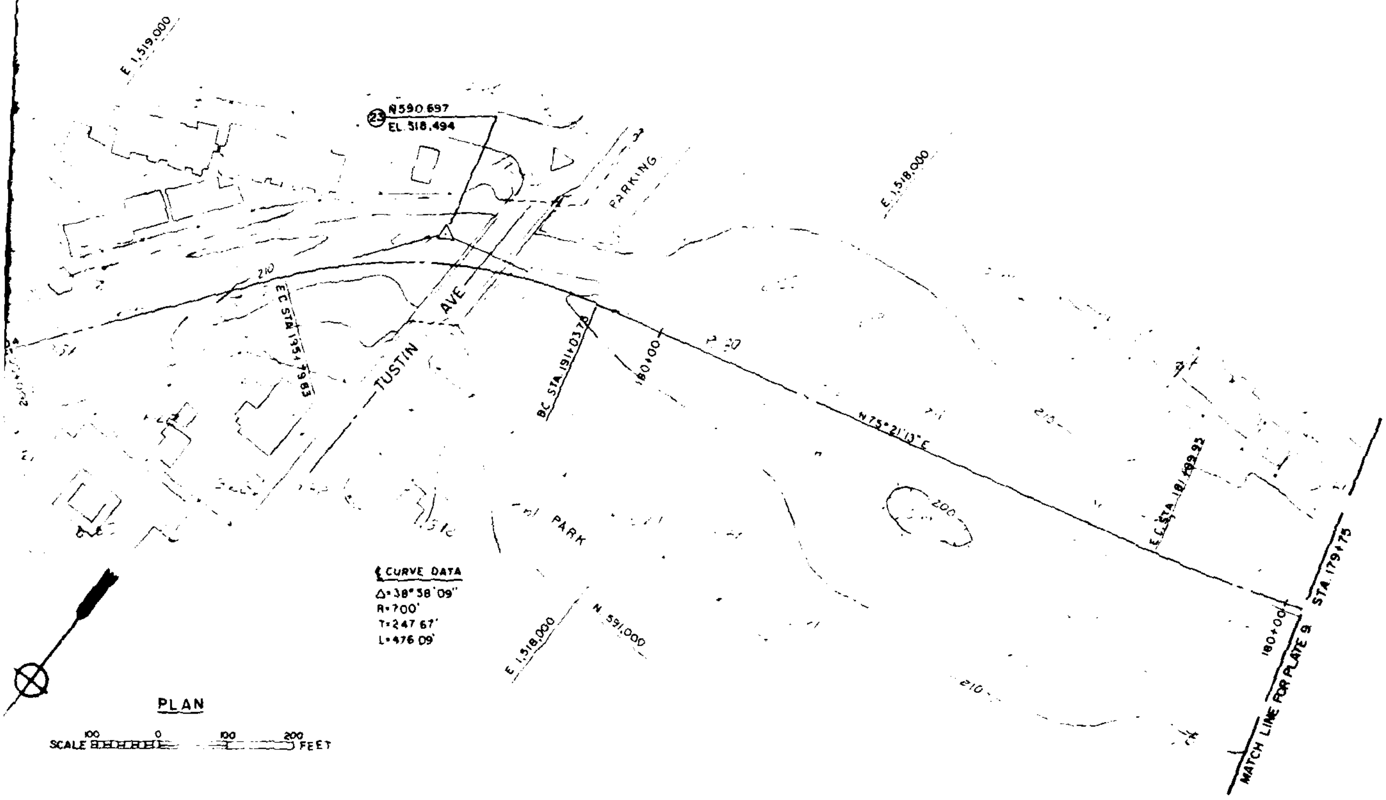
DEPTH	LOG	MC	LL	PI	-4	-200	N	
4.5	SP	2		NP	60	4	R	GRAVELLY SAND: tan, dry, cobbles and boulders to 14 inches.
9.0	SM	2		NP	69	14	R R	SILTY GRAVELLY SAND: brown, dry to damp, cobbles and boulders to 12 inches, some cohesion.
13.5	GP-GM	3		NP	44	6	R	SANDY GRAVEL/SILTY SANDY GRAVEL brown, damp, cobbles and boulders to 12 inches.
15.0	SW-SM	4		NP	50	7	R	GRAVELLY SAND/SILTY GRAVELLY SAND: brown, damp, cobbles and boulders to 14 inches HIT NESTED COBBLES AT 16-0'.



SAFE

UE ENGINEERING PAYS

NOTE:
SEE PLATE 15 FOR LEGEND AND
SOIL CLASSIFICATION



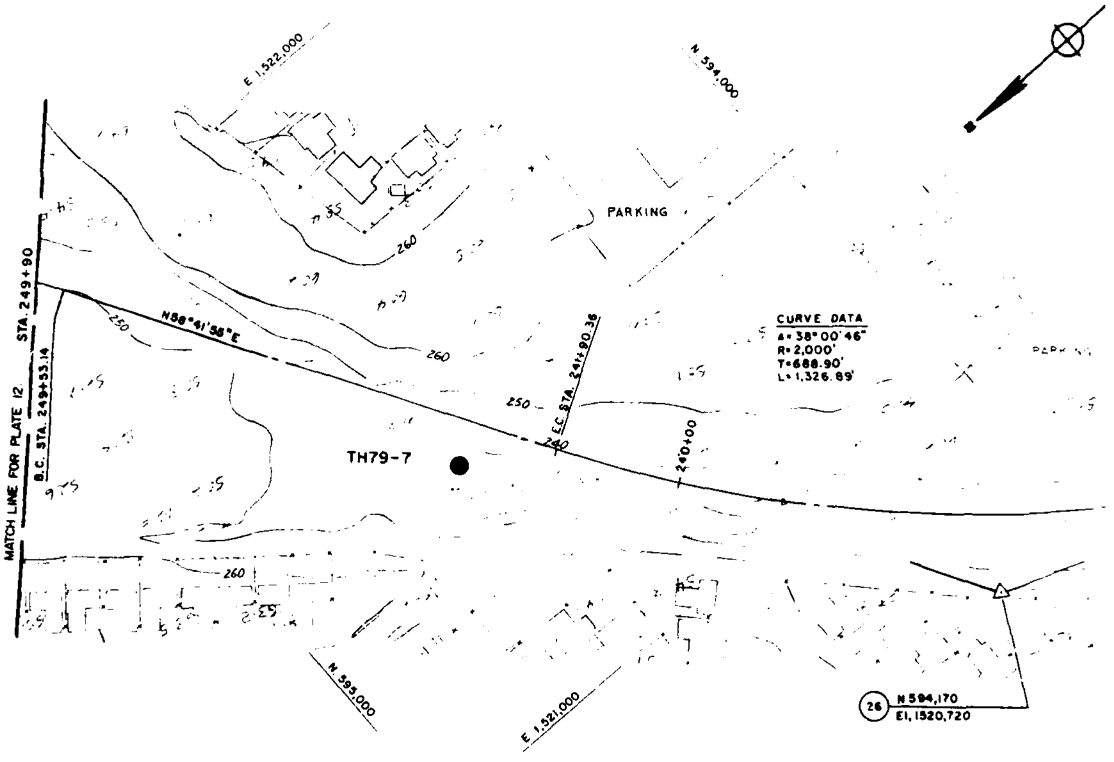
SANTA ANA RIVER BASIN, CALIFORNIA SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)
SANTIAGO CREEK
LOCATIONS AND LOGS OF EXPLORATION STA. 179+75 TO STA. 214+62
U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT

PLATE A-10

SAFETY PAYS

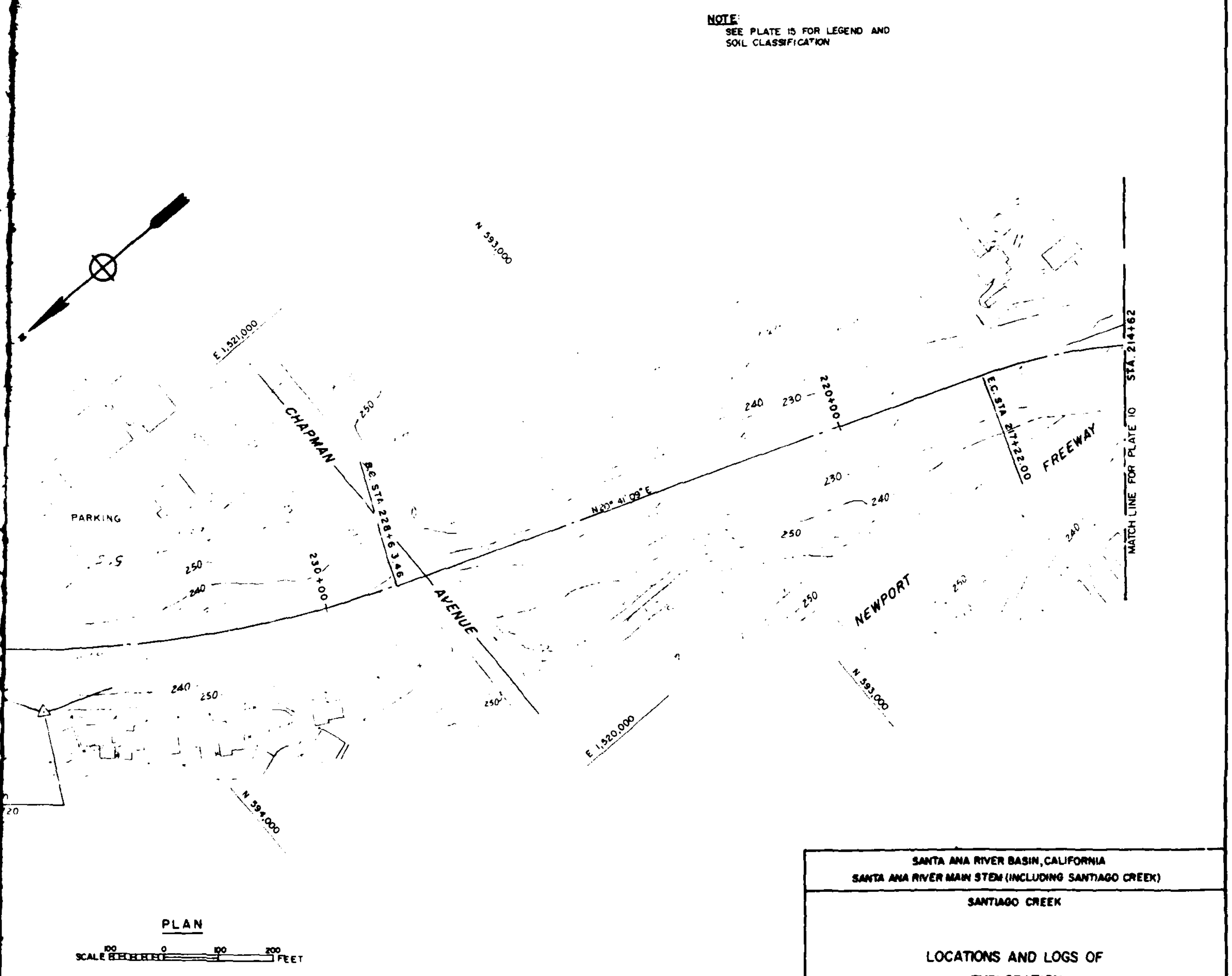
TH79-7

DEPTH	LOG	W%	LL	PI	-4	-200	N	
4.5	SM	5		NP	62	21	R	SILTY GRAVELLY SAND brown, dry to damp, cobbles to 5 inches, some cohesion.
	GW-GM	5		NP	49	10	R R	SANDY GRAVEL/SILTY SANDY GRAVEL dark brown, damp, cobbles and boulders to 12 inches, some cohesion
13.5		6	23	7	42	7	R	dark brown, damp, cobbles and boulders to 13 inches, some cohesion.
18.0	SW-SM	—		NP	57	6	R R	GRAVELLY SAND/SILTY GRAVELLY SAND brown, moist, 10 wet cobbles to 5 inches CAVING AT 13 FEET.



SA

VALUE ENGINEERING PAYS



SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK

LOCATIONS AND LOGS OF EXPLORATION
STA. 214+62 TO STA. [illegible]9+90

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

SAFETY PAYS

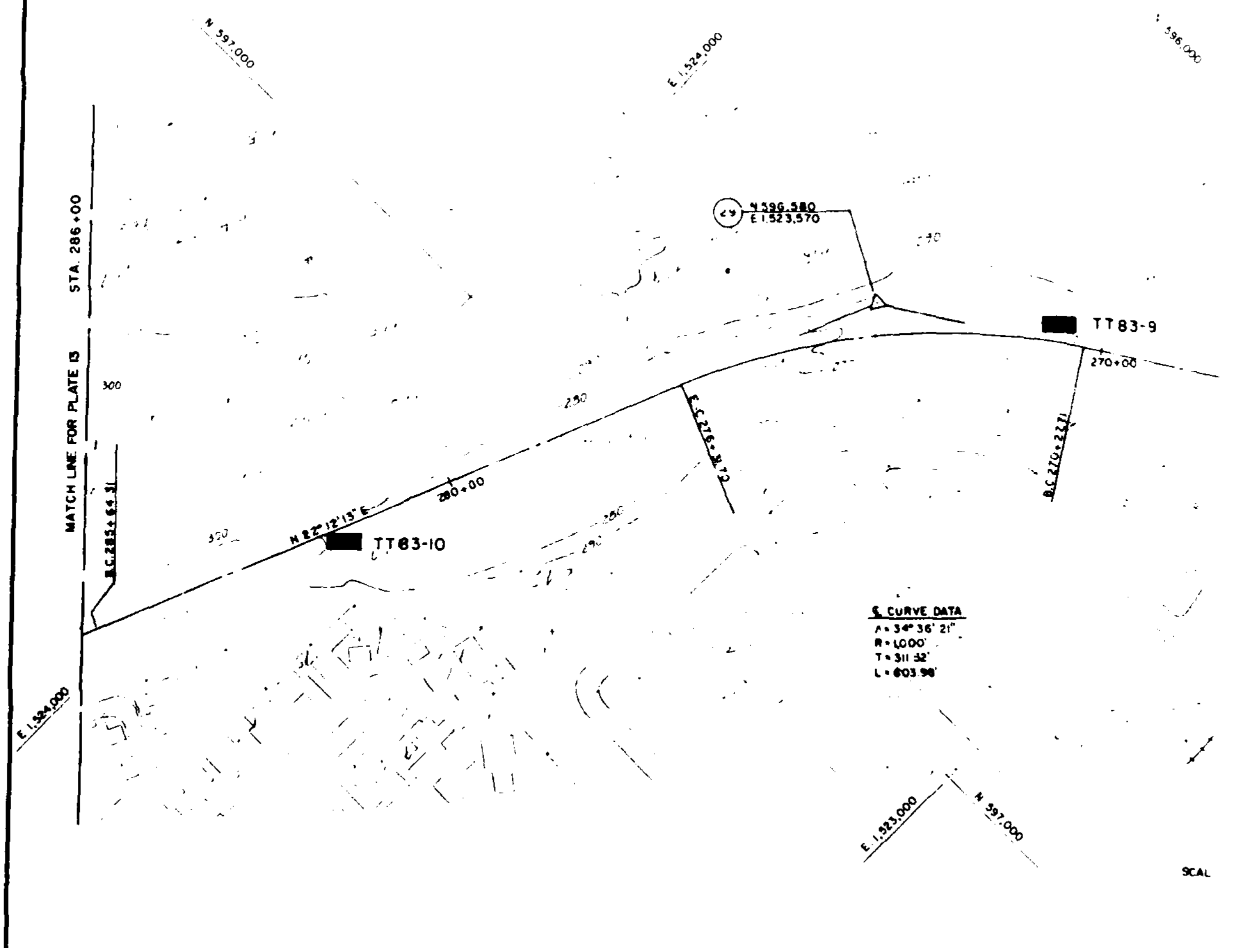
VALUE

TT83 - 10

DEPTH	LOG	LL	PI	-4	-200	DESCRIPTION
7.0	SC	28	13	70	34	GRAVELLY CLAYEY SAND red-brown, damp to moist, dense, fine grained sand, cobbles to 6 inches.
	GW		NP	30	4	SANDY GRAVEL brown, moist, loose, coarse grained to 2 inches, cobbles to 4 inches
10.0	GP	33	15	40	4	
12.0	SP		NP	59	1	GRAVELLY SAND brown, moist, loose, few gravel to 1½ inches
	GW		NP	27	2	SANDY GRAVEL brown, moist, loose, fine grained to 2 inches.
	GP		NP	38	3	
15.5	GW		NP	30	2	medium to fine grained sand.

TT83 - 9

DEPTH	LOG	LL	PI	-4	-200	DESCRIPTION
2.0	GC/GM	26	7	50	21	SILTY SANDY GRAVEL/CLAYEY SANDY GRAVEL brown, moist to wet, cobbles to 4 inches
4.0	GP/GC	33	15	28	7	SANDY GRAVEL/CLAYEY SANDY GRAVEL grey, moist, cobbles to 4 inches, smells organics
11.0	GP/GM		NP	42	6	SANDY GRAVEL/SILTY SANDY GRAVEL tan, moist to wet, few cobbles to 6 inches, increase in moisture as depth increases
14.0	GP		NP	34	2	SANDY GRAVEL tan, moist to wet, gravel to 2 inches
15.0	SP		NP	88	3	SAND tan, moist to wet, loose, medium to fine sand, occasional gravel to 3/4 inches



S

...Y SANDY GRAVEL
...les to 4 inches
...DY GRAVEL grey,
...s, smells organics
...Y GRAVEL tan, moist
... inches, increase in
...oses

...to wet, gravel to

...loose medium to fine
...to 3/4 inches

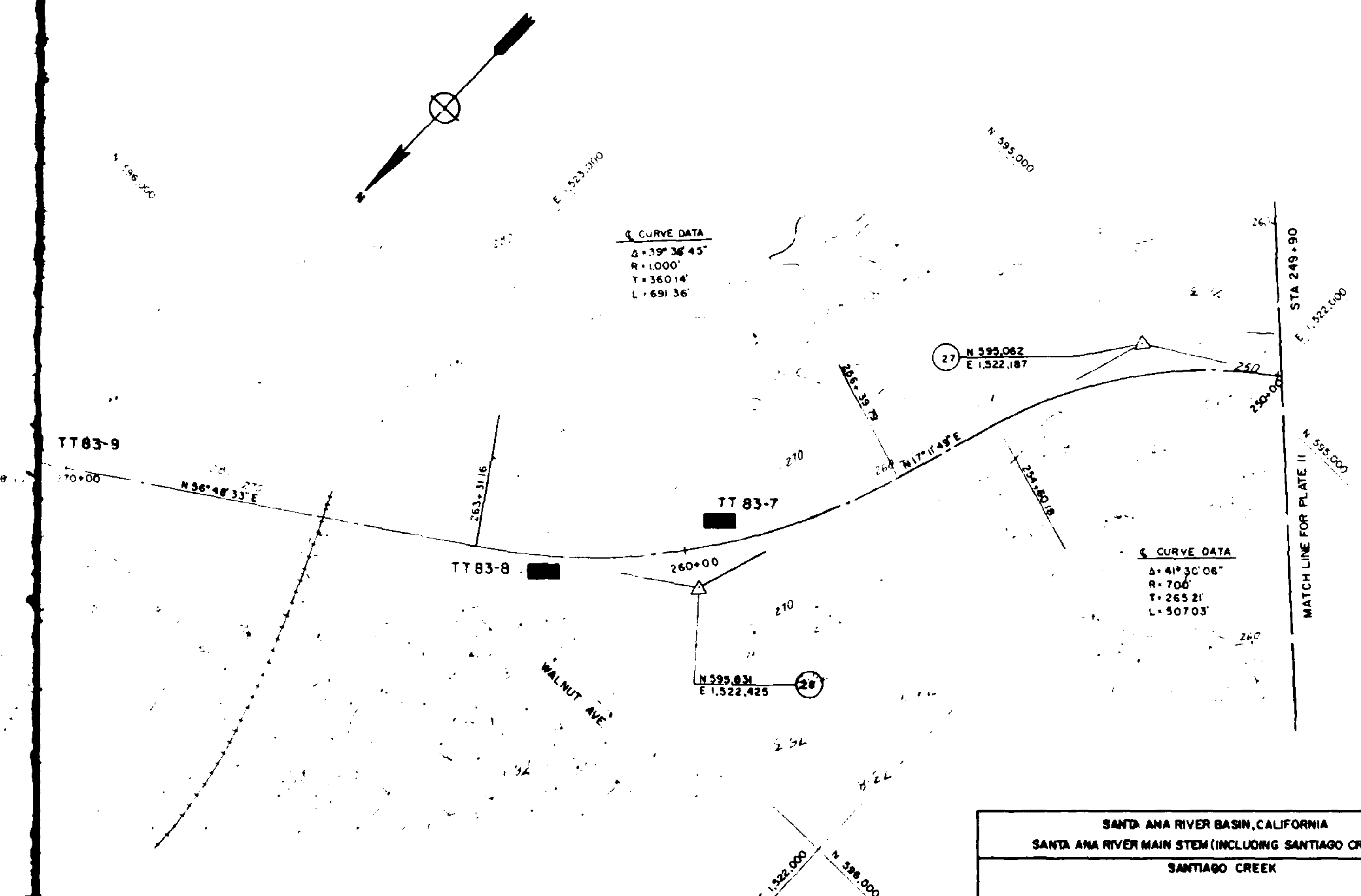
TT83-8

DEPTH	LOG	LL	PI	-4	-200	DESCRIPTION
	GW		NP	23	1	SANDY GRAV... ...ey-brown, dry to damp, cobble... to ... inches
6.0	GW		NP	35	3	tan ... clayey residue covering large aggregate, cobbles to 6 inches, voids to 3 inches around aggregate
	GP		NP	31	1	moist to wet, cobbles to 4 inches
.5	GP		NP	51	3	wet, fine grained to 1 1/2 inches, medium grained sand
13.0	GW GM		NP	36	5	SANDY GRAVEL/SILTY SANDY GRAVEL tan, wet

TT83-7

DEPTH	LOG	LL	PI	-4	-200	DESCRIPTION
2.25	GW		NP	14	1	GRAVEL grey, moist to wet, loose, gravel to 1 1/2 inches, coarse grained sand, some brown clayey fines
5.0	GP/GC	27	11	50	5	SANDY GRAVEL/CLAYEY SANDY GRAVEL brown, moist, gravel to 1 1/2 inches, medium grained sand, occasional cobbles and boulders
10.0	GW	36	17	24	4	SANDY GRAVEL brown, moist, gravel to 1 1/2 inches
11.0	GP/GC	41	24	25	6	SANDY GRAVEL/CLAYEY SANDY GRAVEL light brown, wet, gravel to 1 1/2 inches
11.5	SC/SM	25	6	79	30	GRAVELLY SILTY SAND/GRAVELLY CLAYEY SAND reddish brown, gravel to 1 1/2 inches
15.0	GP/GC	28	8	35	5	SANDY GRAVEL/CLAYEY SANDY GRAVEL brown, moist, gravel to 1 1/2 inches

NOTE:
SEE PLATE 15 FOR LEGEND AND SOIL CLASSIFICATION.



PLAN

SCALE 100 0 100 200 FEET

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)
SANTIAGO CREEK

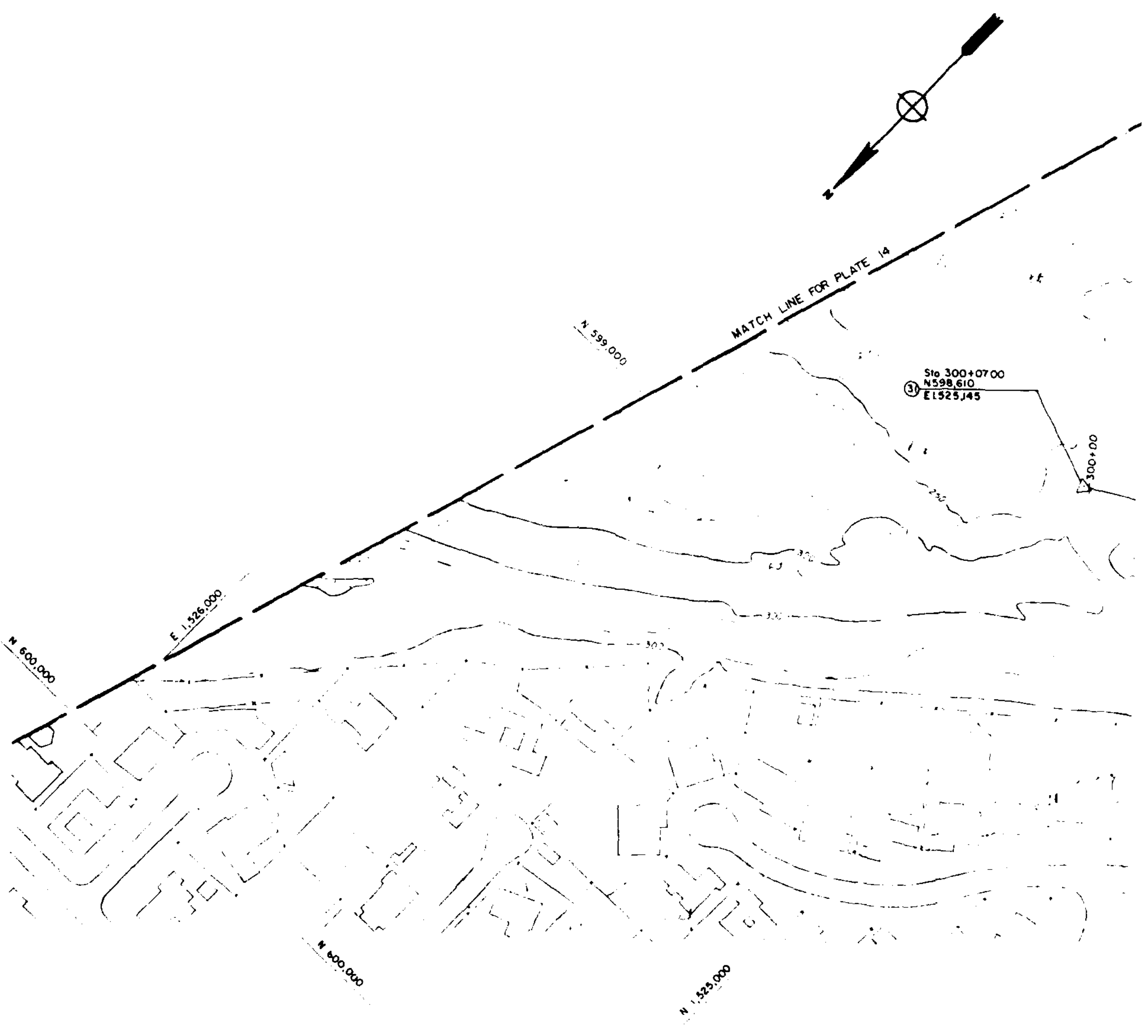
LOCATIONS AND LOGS OF EXPLORATION
STA. 249+90 TO STA. 286+00

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

VALUE EN

NOTES

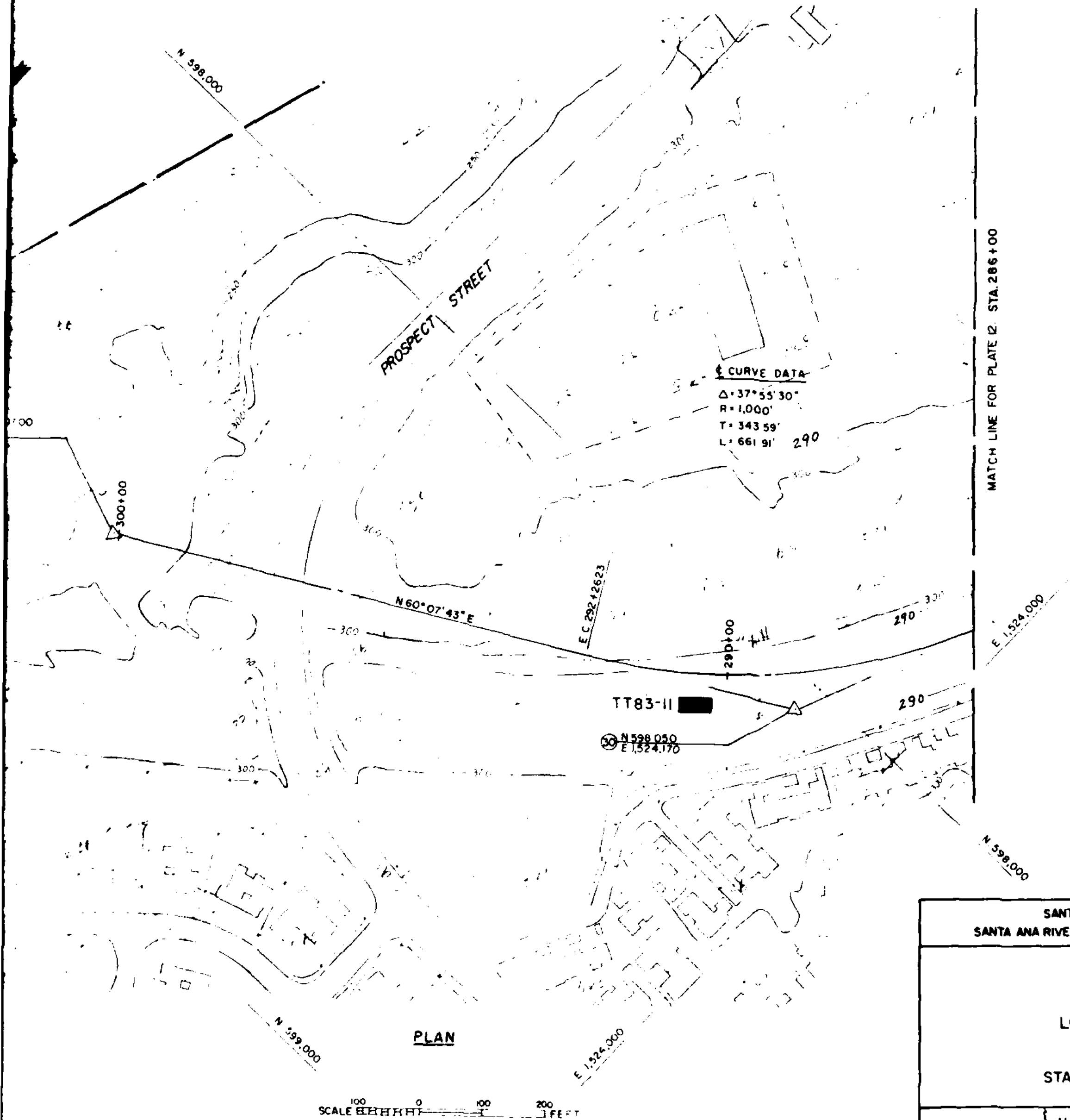
1. See Plate for legend and Soil Classification.
2. Test holes drilled on top of bank in 1979.
   Test trenches dug in invert in 1983.



SAF

TT83-II

DEPTH	LOG	LL	PI	-4	-200	DESCRIPTION
	SC/SM	21	4	65	28	SILTY GRAVELLY SAND/CLAYEY GRAVELLY SAND rust, damp, dense, fine grained, coarse grained gravel to 2 inches, few cobbles to 9 inches.
3.5		23	5	65	26	
5.25	ML	24	2	95	54	orange-brown, damp to moist, medium dense, fine grained gravel to 2 inches.
						SANDY SILT brown damp, very stiff, fine grained sand, occasional gravel to 1/2 inch
11.0	GP/GC	34	14	46	9	SANDY GRAVEL/CLAYEY SANDY GRAVEL red-brown, damp, dense, fine grained to medium grained sand, few cobbles, occasional boulders to 13 inches.
12.0	SP		NP	51	2	GRAVELLY SAND brown, damp, loose, medium grained, fine grained gravel to 2 inches.
	GP		NP	50	2	SANDY GRAVEL brown, damp, loose, fine grained to 3 inches, medium grained sand.
15.0			NP	46	3	



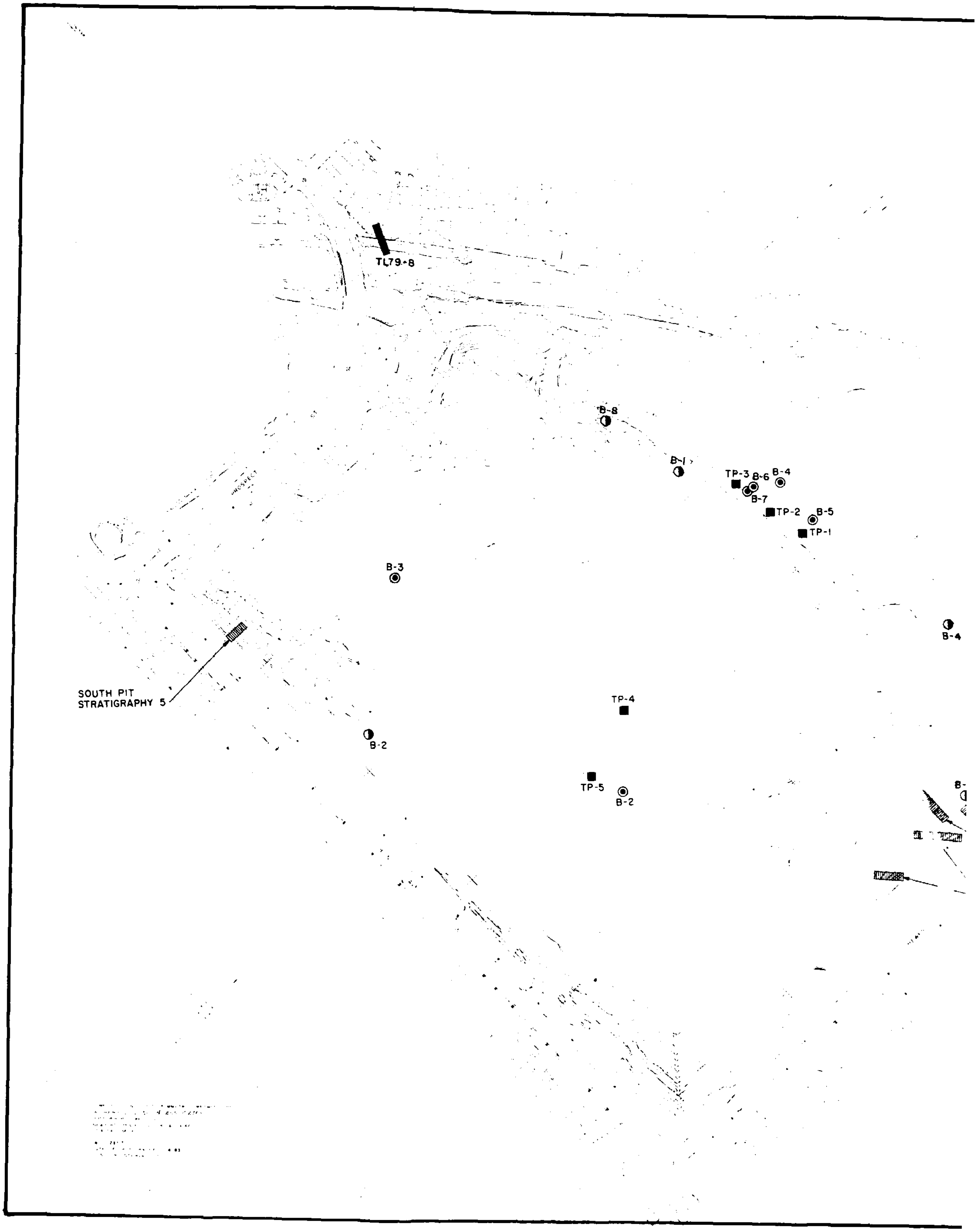
SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK

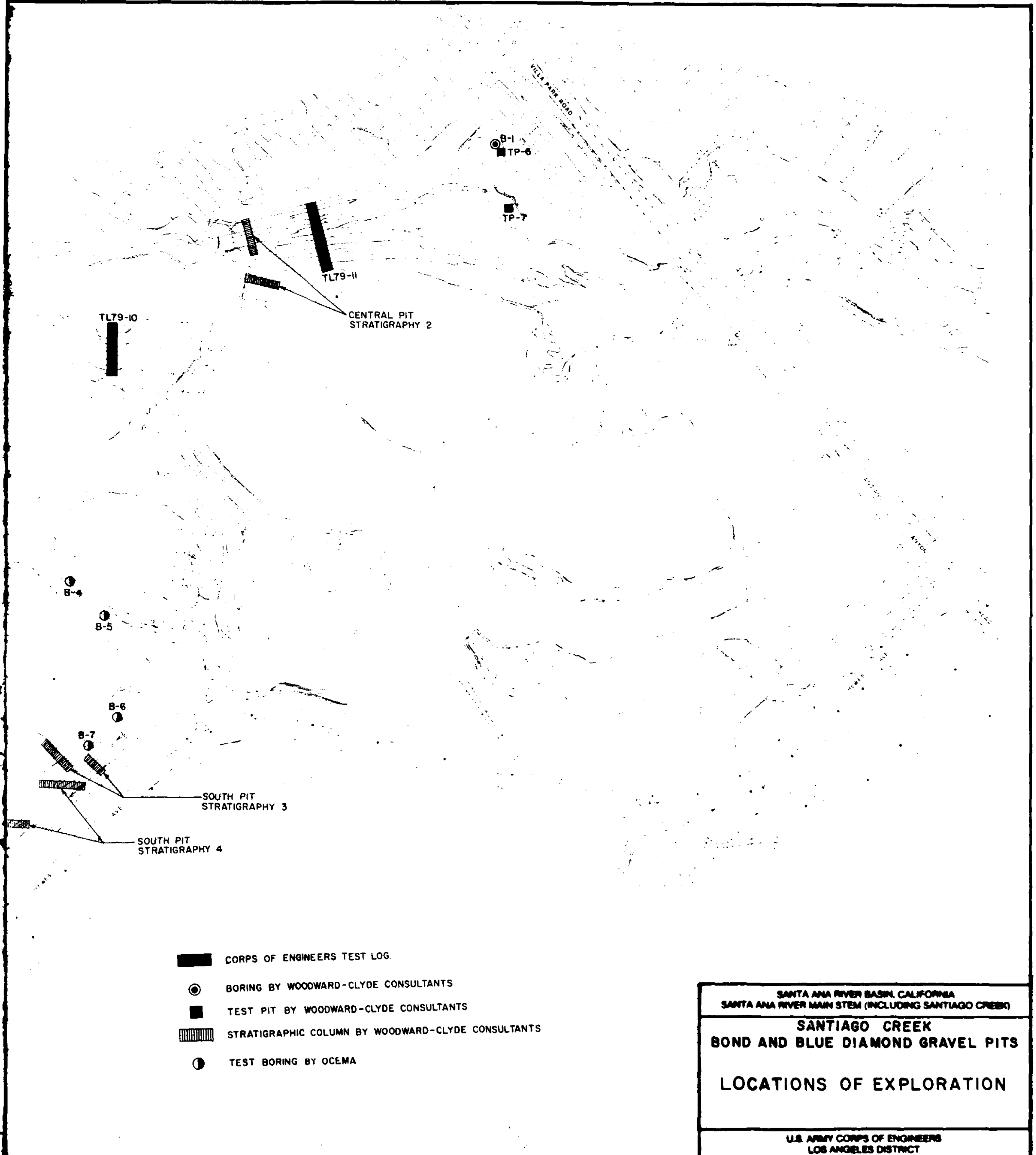
LOCATIONS AND LOGS OF EXPLORATION

STA. 286+00 TO STA. 300+07

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



TL79-8
B-8
B-1
TP-3
B-6
B-4
B-7
TP-2
B-5
TP-1
B-3
B-4
SOUTH PIT
STRATIGRAPHY 5
TP-4
B-2
TP-5
B-2



SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK
BOND AND BLUE DIAMOND GRAVEL PITS

LOCATIONS OF EXPLORATION

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

TL 79-8

EL. 310.10±	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
10.0'	GM	-		NP	49	15		SILTY SANDY GRAVEL: Tan, rounded cobbles to 8 inches dense.
20.0'	GP	-		NP	43	2		SANDY GRAVEL: Tan, cobbles to 4 inches, gravel to 1 inch, medium-dense.

TL 79-10

EL. 320.0±	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
10.0'	GP-GM	-		NP	55	12		SANDY GRAVEL-SILTY SANDY GRAVEL: Gravel to 3 inches, medium dense.
40.0'	GP-GM	-		NP	36	7		SANDY GRAVEL-SILTY SANDY GRAVEL: Tan, dense, cobbles to 6 inches, gravel to 3 inches.

TL 79-12

EL. 315.0±	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
5.0'	CL	-	26	8	99	62		SANDY CLAY: Red-brown, stiff, some gravel to 1 inch.
25.0'	GP-GM	-		NP	49	8		SANDY GRAVEL-SILTY SANDY GRAVEL: Tan, cobbles to 9 inches, gravel to 3 inches.

TL 79-9

EL. 310.0±	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
20.0'	SM	-		NP	68	31		SILTY GRAVELLY SAND Tan, cobbles to 6 inches, rounded gravel to 2 inches, dense.
40.0'	SM	-		NP	92	44		SILTY SAND Tan, rounded gravel to 2 inches, dense
50.0'	GP	-		NP	38	4		SANDY GRAVEL Gray, dense, cobbles to 9 inches, rounded gravel to 3 inches
70.0'	GM	-		NP	61	23		SILTY SANDY GRAVEL Gray, dense, cobbles to 4 inches, gravel to 3 inches
90.0'	GW-GM	-		NP	46	10		SANDY-GRAVEL-SILTY SANDY GRAVEL Gray-tan dense, cobbles to 9 inches, gravel to 3 inc
120.0'	GP-GM	-		NP	37	11		SANDY GRAVEL-SILTY SANDY GRAVEL Gray-tan boulders to 12 inches gravels to 3 inches

Tan, cobbles
gravel to 2

nded gravel to

dense, cobbles to
avel to 3 inches.

Gray, dense, cobbles
to 3 inches.

Y SANDY GRAVEL: Gray-tan
9 inches, gravel to 3 inches.

Y SANDY GRAVEL: Gray-tan, dense,
hes, gravels to 3 inches.

TL 79-11

EL 3200±	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP	-		NP	62	2		GRAVELLY SAND: Tan, gravel to 3 inches, dense.
10.0'	GW	-		NP	34	2		SANDY GRAVEL: Tan-gray, cobbles to 8 inches, gravel to 3 inches, dense.
40.0'	SP	-		NP	70	4		GRAVELLY SAND: Tan, gravel to 2 inches, dense.
60.0'	CL	-	49	23	81	54		GRAVELLY SANDY CLAY: Tan, gravel to 2 inches, dense.
80.0'	SW-SM	-		NP	60	7		GRAVELLY SAND-SILTY GRAVELLY SAND Brown-gray cobbles to 6 inches, gravel to 3 inches.
100.0'								

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than half of material is larger than no. 200 sieve size.	GRAVELS More than half of coarse fraction is larger than no. 4 sieve size.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction is smaller than no. 4 sieve size.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than half of material is smaller than no. 200 sieve size.	SILTS AND CLAYS	Low liquid limit.	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
			OL	Organic silts and organic silty clays of low plasticity.
		High liquid limit.	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity.
			OH	Organic clays of medium to high plasticity, organic silts.
Highly organic soils			Pt	Peat and other highly organic soils.

NOTES:

1. Boundary Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC, well-graded gravel-sand mixture with clay binder.
2. All sieve sizes on this chart are U. S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus no. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart, and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. The Soil Classification System is based on the American Society for Testing and Materials (ASTM)
   a. (ASTM) D2487 Standard Test Method for Classification of Soils for Engineering Purposes.
   b. (ASTM) D2488 Standard Recommended Practice for Description of Soils (Visual Manual Procedure)

LEGEND

T. H.
● LOCATION AND NUMBER OF TEST HOLE
MC FIELD MOISTURE CONTENT IN PERCENT OF DRY WEIGHT.
LL LIQUID LIMIT.
PI PLASTICITY INDEX (LIQUID LIMIT MINUS PLASTIC LIMIT).
NP NONPLASTIC
-4 PERCENT OF MATERIAL BY WEIGHT PASSING NO. 4 SIEVE.
-200 PERCENT OF MATERIAL BY WEIGHT PASSING NO. 200 SIEVE.
N NUMBER OF BLOWS OF A 140-POUND DROPHAMMER FALLING 30 INCHES REQUIRED TO DRIVE A SAMPLING SPOON ONE FOOT. OUTSIDE DIAMETER OF SPOON IS 2 INCHES; INSIDE DIAMETER IS 1-3/8 INCHES. PROCEDURE IS CALLED STANDARD PENETRATION TEST.
W DEPTH TO WATER

NOTES

1. Test logs sampled from pit walls in October, 1979
2. See plate for location of test logs.

SCALE 5 0 5 10 15 FEET

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)
SANTIAGO CREEK
BOND AND BLUE DIAMOND GRAVEL PITS

LOGS OF EXPLORATION
TL 79-8 TO TL 79-12
CORPS OF ENGINEERS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

KEY TO BORING LOGS

DEPTH, FT	SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
			SURFACE ELEVATION				
	1	25	Medium dense, moist, brown SILTY SAND (SM)				
	2	10		2.0			MA
5	3			2.0*			

Unified Soil Classification

Standard Penetrometer Location

Laboratory Unconfined Compressive Strength

Modified California Sample Location

Pocket Penetrometer Strength

Shelby Tube Sample Location

Number of Blows Required to Advance Sampler One Foot

Tube Sample Location

Sample Number

Indicates Sample Tested for Other Properties

CONS – Consolidation Test

LL – Liquid Limit,

MA – Mechanical Analysis, percentage passing No. 200 sieve by weight indicated in parenthesis

PI – Plasticity Index

CORR – Corrosivity Test

SA – Sieve Analysis, percentage passing No. 200 by weight indicated in parenthesis

WA – Wash Analysis percentage passing No. 200 sieve by weight indicated in parenthesis

NOTES ON FIELD INVESTIGATION

1. Borings were drilled with a truck mounted drill rig using a Mobile 51 and CME 55, 8-inch diameter, hollow stem auger.
2. Samples with recorded blow/penetration were obtained with a Modified California (2-inch inside diameter, 2½-inch outside diameter), and Standard Penetration sampler. The sampler was driven into the soil at the bottom of the hole with a 140 pound hammer falling 30 inches.
3. Samples labeled Sk were obtained by collecting cuttings in a cloth bag.
4. Classifications are based upon the Unified Soil Classification System and include color, moisture, and consistency. Field descriptions have been modified to reflect results of laboratory analyses where deemed appropriate.
5. No free groundwater was encountered at the time of drilling.
6. Descriptions on these boring logs apply only at the specific boring locations and at the time the borings were made. They are not warranted to be representative of subsurface conditions at other locations or times.

LOG OF BORING B-1

DATE OF BORING 4-10-85 WATER DEPTH Not encountered DATE MEASURED

TYPE OF DRILL RIG Mobile B-80 Hollow Stem Auger HOLE DIAMETER 8 inches

WEIGHT OF HAMMER 140 pounds FALLING 30 inches SAMPLES Standard Penetration Test, Shelby, Modified California

DEPTH, FT	SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
			SURFACE ELEVATION Approximately 280 feet				
	1	23	Medium dense damp SANDY SILT (ML)	8* 3.2	14	107	COR
5	2	20		1.5*			
10	3				21	107	
	4	28		1.3*			
15	5	52/3"	Very dense damp brown SAND (SP) with gravel				
	6	78					
20			Bottom of boring at 20 feet				
25							

LOG OF BORING B-4

DATE OF BORING 4-23-85 WATER DEPTH Not encountered DATE MEASURED -

TYPE OF DRILL RIG CME 55 Hollow Stem Auger HOLE DIAMETER 8 inches

WEIGHT OF HAMMER 140 pounds FALLING 18 inches SAMPLES Standard Penetration Test, Shelby, Modified California

DEPTH, FT	SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
			SURFACE ELEVATION Approximately 286 feet				
			Stiff damp light brown SANDY CLAY (CL)				
5	1	15		7.2*	31	92	
10	2	18	Becomes very stiff				MA (99)
15	3			2.7	39	81	
	4	7	Becomes medium stiff				
20	5	6		1*	48	74	
25	6	11	Medium dense wet dark brown to dark grayish brown SILTY SAND (SM)		19	104	
30	7						
	8	17					
35	9	12	Stiff, damp dark brown SANDY CLAY (CL)		39	82	
40	10	13		1.5*			
45							
50			Stiff, damp, dark brown SANDY CLAY (CL)				
	11			0.3	33	88	
	12	9	Becomes more sandy				
55							
60			Becomes gravelly				
65	13	46	Very dense, moist gray SANDY GRAVEL (GP) (Qos)	4*	24	100	
			Bottom of Boring at 67 feet				
70							

LOG OF BORING B-5

DATE OF BORING 4-22-85 WATER DEPTH Not encountered DATE MEASURED -

TYPE OF DRILL RIG CME 55 Hollow Stem Auger HOLE DIAMETER 8 inches

WEIGHT OF HAMMER 140 pounds FALLING 18 inches SAMPLES Standard Penetration Test, Shelby, Modified California

DEPTH, FT	SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
			SURFACE ELEVATION Approximately 287 feet				
			Soft, damp, dark brown SANDY CLAY (CH)				
5	1			5*			
	2	4		4.5	31	92	
10			Medium dense, dry brown SILTY SAND (SM)				
	3	27			20	94	
15							
	4	6					
20							
	5	30					
25			Damp dense, dark gray CLAYEY SAND (SC)	3*	20	93	
	6						
30	7	6	Soft, wet brown SANDY CLAY (CH)				
	8	4					
35			Becomes medium stiff				
	9	5		1*	35	84	
40							
	10						CO
45	11	8			43		LL PI
50							
	12	12	Becomes stiff brown SANDY CLAY (CL)	0.5*	27	[illegible]	
55			Very dense dry CLAYEY SAND (SC) with gravel				
60							
	13						
65	14	96/8"			24	100	
			Bottom of Boring at 66 feet				
70							

…d. DATE MEASURED ______
…ER 8 inches
Standard Penetration Test, Shelby, Modified California

UNC COMP STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
9* 3.2	14	107	CORR
7.5*			
	21	107	
7.3*			

LOG OF BORING B-2

DATE OF BORING 4-10-85 WATER DEPTH Not encountered DATE MEASURED –
TYPE OF DRILL RIG Mobile B-80 Hollow Stem Auger HOLE DIAMETER 8 inches
WEIGHT OF HAMMER 140 pounds FALLING 30 inches SAMPLES Standard Penetration Test, Shelby, Modified California

SURFACE ELEVATION Approximately 183 feet

SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC COMP STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
1	5	Loose, moist, light brown SILTY SAND (SM)	2*			MA (20) LL=24 PI=1
2	1	Very soft, wet, tan to grayish brown SANDY CLAY (CL)		18	89	
3	0	Becomes (CL-CH)		74	54	
4	2					
5	10	Loose, wet, grayish brown CLAYEY SAND (SC)		31	89	WA (39)
6	50/4.5"	Becomes very dense, less clayey, with gravel		12	121	
	50/2"	Becomes damp				
		Bottom of boring at 30 feet				

LOG OF BORING B-3

DATE OF BORING 4-10-85 WATER DEPTH Not encountered DATE MEASURED ______
TYPE OF DRILL RIG Mobile B-80 Hollow Stem Auger HOLE DIAMETER 8 inches
WEIGHT OF HAMMER 140 pounds FALLING 30 inches SAMPLES Standard Penetration Test, Shelby, Modified California

SURFACE ELEVATION Approximately 206 feet

SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC COMP STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
1	8	Loose, damp, brown SILTY SAND (SM)		17	86	
2	2	Becomes very loose				
		Becomes wet				
	10					MA (6)
		Becomes loose to medium dense		33	86	
5	11	With 2" thick CLAY lens				
6						
7	3	Soft, wet, brown SILTY CLAY (CL)				LL=46 PI=…
8	2	Becomes SANDY CLAY (CL)		32	90	
9	7	Becomes medium stiff		50	72	
10						
11	6		1*	58	66	
		Becomes gravelly				
		Very dense, moist, grey SANDY GRAVEL (GP) (Qoa)				
		Bottom of Boring at 53 feet				

: DATE MEASURED ______
…ER 8 inches
Standard Penetration Test, Shelby, Modified California

UNC COMP STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
5* 4.5	31	82	LL=61 PI=35
	20	94	
3*	20	83	
1*	35	84	
	43		CONS LL=98 PI=33
0.5*	27	98	
	24	100	

LOG OF BORING B-6

DATE OF BORING 4-23-85 WATER DEPTH Not encountered DATE MEASURED –
TYPE OF DRILL RIG CME 56 Hollow Stem Auger HOLE DIAMETER 8 inches
WEIGHT OF HAMMER 140 pounds FALLING 18 inches SAMPLES Standard Penetration Test, Shelby, Modified California

SURFACE ELEVATION Approximately 280 feet

SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC COMP STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
		Medium stiff, moist, brown SANDY CLAY (CH)				
1	9		7*	27	90	
2						
3	7			37		LL=80 PI=35 CONS
4	9	Becomes stiff	2*			
5	11		1.2*	36	85	
		Becomes gravelly				
6	50/5"	Very dense, grey SANDY GRAVEL (GP) (Qoa)				
		Bottom of Boring at 41.5 feet				

LOG OF BORING B-8

DATE OF BORING 4-23-85 WATER DEPTH Not encountered DATE MEASURED ______
TYPE OF DRILL RIG CME 56 Hollow Stem Auger HOLE DIAMETER 8 inches
WEIGHT OF HAMMER 140 pounds FALLING 18 inches SAMPLES Standard Penetration Test, Shelby, Modified California

SURFACE ELEVATION Approximately 283 feet

SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC COMP STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
		Very soft, damp, dark brown SILTY CLAY (CL-CH)				
1				46	73	
2	2	Becomes wet				MA (99)
3	1			55	70	
4	3					
5						
6	4			46	75	
7	6			38	81	LL=50 PI=28
		Bottom of Boring at 50.5 feet				

LOG OF BORING B-7

DATE OF BORING 4-23-85 WATER DEPTH Not encountered DATE MEASURED –
TYPE OF DRILL RIG CME 56 Hollow Stem Auger HOLE DIAMETER 8 inches
WEIGHT OF HAMMER 140 pounds FALLING 18 inches SAMPLES Standard Penetration Test, Shelby, Modified California

SURFACE ELEVATION Approximately 280 feet

SAMPLES	BLOWS/FOOT	DESCRIPTION	UNC COMP STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
		Dense, dry, brown SANDY gravel (GW) (Qoa)				
		Bottom of Boring at 8.5 feet				

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK
BOND AND BLUE DIAMOND GRAVEL PITS

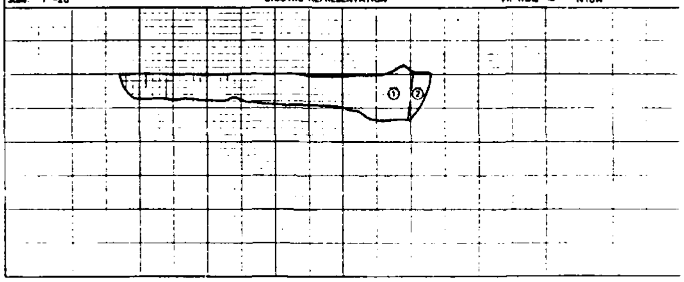
LOGS OF BORINGS B-1 THROUGH B-8
DEVELOPED BY WOODWARD-CLYDE CONSULTANTS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

Excavated By: OCWD	Geologist / Engineer: Sonja Donaldson	Woodward-Clyde Consultants	Project: SANTIAGO CREEK	
Equipment Used: Case 700 Backhoe	Shoring:	LOG OF TEST PIT NO. 1	Project No.: 41908A	Figure No.: A 13

Description	Physical Condition	Attitudes	Samples
(1) Stiff, damp, dark brown CLAY (CL), thinly laminated, bedding appears to be close to horizontal	Unit 1 Unit 2 contact	82-85NW	SK 20 (same material)
(2) Damp, medium brown CLAYEY SAND (SC) with gravel to 3", few cobbles to 12"			
*Logged from surface			

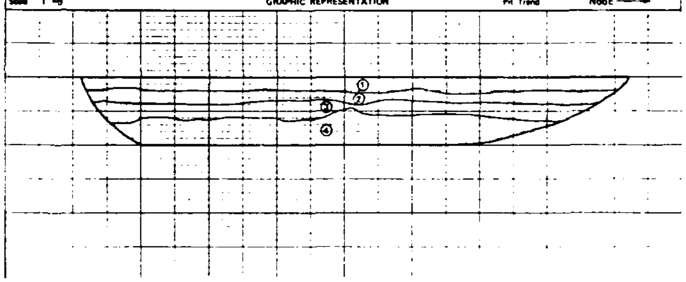
Scale: 1"=20' GRAPHIC REPRESENTATION Pit Trend ← N16W



Excavated By: OCWD	Geologist / Engineer: Sonja Donaldson	Woodward-Clyde Consultants	Project: SANTIAGO CREEK	
Equipment Used: Case 700 Backhoe	Shoring:	LOG OF TEST PIT NO. 4	Project No.: 41908A	Figure No.: A 16

Description	Physical Condition	Attitudes	Samples
(1) Dry, light brown, thinly laminated SILT (ML) with CLAY			
(2) Dry, loose, thinly bedded SAND (SP) with some gravel to ½"			
(3) Damp SILTY SAND (SM) with CLAY, gravel to 6", some bedding near bottom of unit			
(4) Reddish brown CLAYEY SILT (SM) with some gravel to 1"			
Bedding appears to dip a few degrees to NW			
*Logged from surface			

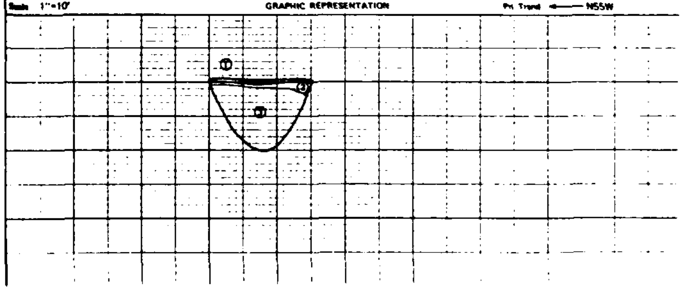
Scale 1"=5' GRAPHIC REPRESENTATION Pit Trend N66E →



Excavated By: OCWD	Geologist / Engineer: Sonja Donaldson	Woodward-Clyde Consultants	Project: SANTIAGO CREEK	
Equipment Used: Case 700 Backhoe	Shoring:	LOG OF TEST PIT NO. 6	Project No.: 41908A	Figure No.: A-18

Description	Physical Condition	Attitudes	Samples
(1) Thin layer fill (pea gravel and ¾ gravel) (GP)			SK 27
(2) Thin layer (6"-1') of light tan, medium dense SILTY SAND (SM) with clay and gravel to 5"			M 26
(3) Massive, dark reddish brown SILT (ML) with CLA-			
*Logged from surface			

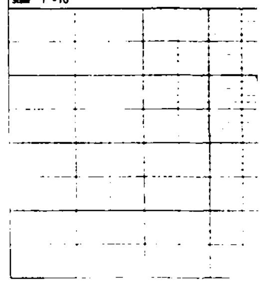
Scale 1"=10' GRAPHIC REPRESENTATION Pit Trend ← N55W



Excavated By: OCWD	Geologist / Engineer: Sonja Donaldson
Equipment Used: Case 700 Backhoe	Shoring:

Description
(1) Stiff, damp, dark brown CLAY (CL) [illegible]
(2) Damp, medium brown CLAYEY SAND (SC) with gravel [illegible]
*Logged from surface

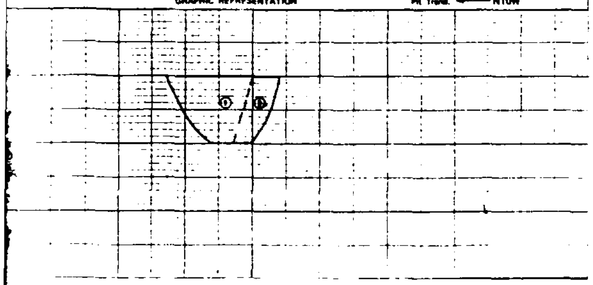
Scale 1"=10'



Geologist / Engineer: Sonja Donaldson	Woodward-Clyde Consultants	Project: SANTIAGO CREEK	
Shoring	LOG OF TEST PIT NO. 2	Project No. 41908A	Figure No. A-14

Description	Physical Condition	Attitudes	Samples
[illegible] brown CLAY (CL) (thin horizontal lamination)	Sump-alluvial contact in	N80E	
	TP-1 to Sump-alluvial		
	contact in TP-2		
[illegible] CLAYEY SAND (SC) with gravel to 3", few cobbles to 12"	Dip of contact between	70-75NW	
	Unit 1 and Unit 2 in		
	TP-2		

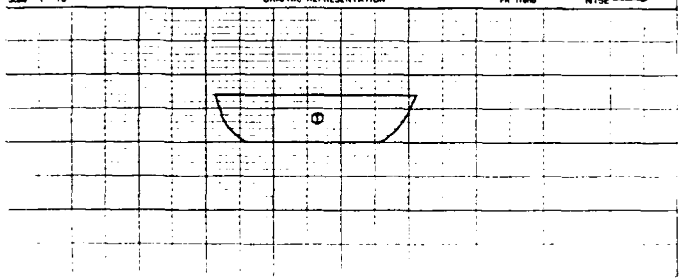
GRAPHIC REPRESENTATION — Pit Trend ← N10W



Excavated By: OCWD	Geologist / Engineer: Sonja Donaldson	Woodward-Clyde Consultants	Project: SANTIAGO CREEK	
Equipment Used: Case 700 Backhoe	Shoring	LOG OF TEST PIT NO. 3	Project No. 41908A	Figure No. A-15

Description	Physical Condition	Attitudes	Samples
(1) Damp, brown CLAYEY SILT (ML) with some gravel to 2", few cobbles to 8"			
*Logged from surface			

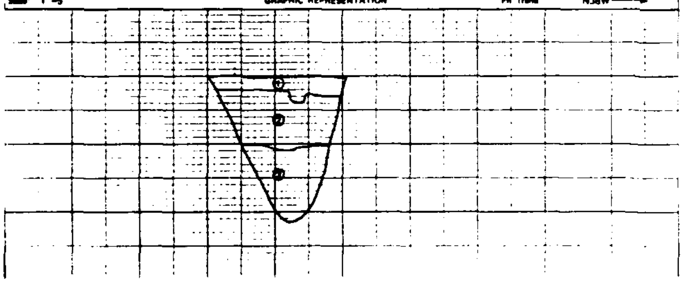
Scale 1"=10' — GRAPHIC REPRESENTATION — Pit Trend N15E →



Excavated By: OCWD	Geologist / Engineer: Sonja Donaldson	Woodward-Clyde Consultants	Project: SANTIAGO CREEK	
Equipment Used: Case 700 Backhoe	Shoring	LOG OF TEST PIT NO. 5	Project No. 41908A	Figure No. A-17

Description	Physical Condition	Attitudes	Samples
(1) Dry, loose, light tan SILT (ML), thinly laminated			SK 25
(2) Damp, light tan SILT (ML)			
(3) Wet, soft, medium brown CLAY (CL) (some thin lamination); no seepage			
*Logged from surface			

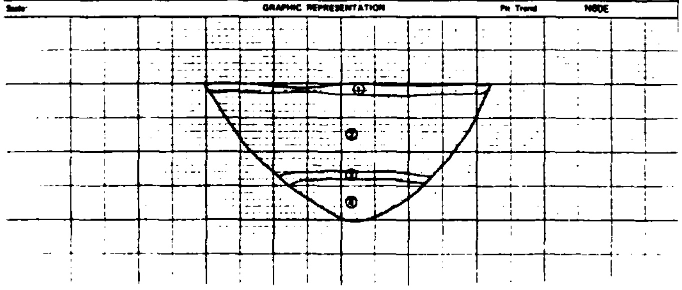
Scale 1"=5' — GRAPHIC REPRESENTATION — Pit Trend N38W →



Excavated By: OCWD	Geologist / Engineer: Sonja Donaldson	Woodward-Clyde Consultants	Project: SANTIAGO CREEK	
Equipment Used: Case 700 Backhoe	Shoring	LOG OF TEST PIT NO. 7	Project No. 41908A	Figure No. A-19

Description	Physical Condition	Attitudes	Samples
(1) 6" layered light gray pea gravel (GP)	Matrix becomes fine		SK 27
	grained and more		
	massive downward		
(2) Light brown to gray SAND (SP) with gravel to 6", some silt			
(3) 2"-3" thick layer of ½"-2" GRAVEL (GP) with some SILT matrix			
(4) CLAYEY SAND (SC) with gravel to 4"			
*Logged from surface			

Scale — GRAPHIC REPRESENTATION — Pit Trend N80E



SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK
BOND AND BLUE DIAMOND GRAVEL PITS

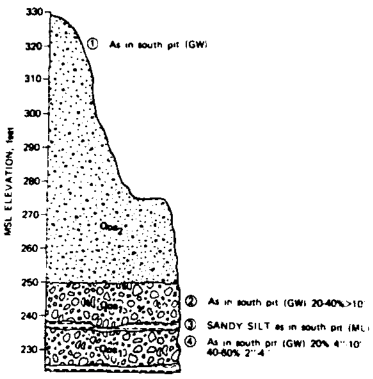
LOGS OF TEST PITS
NO. 1 THROUGH NO. 7
DEVELOPED BY WOODWARD-CLYDE CONSULTANTS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

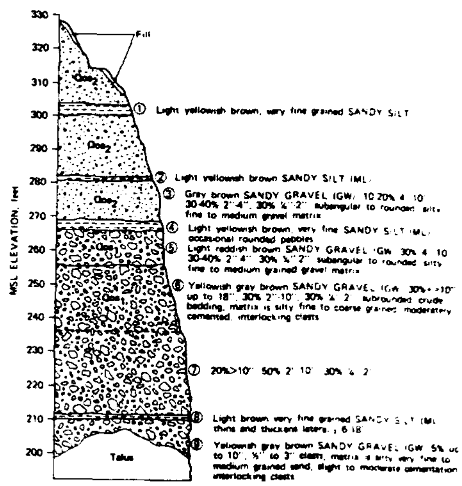
PLATE A-17

VALUE

LEGEND FOR STR

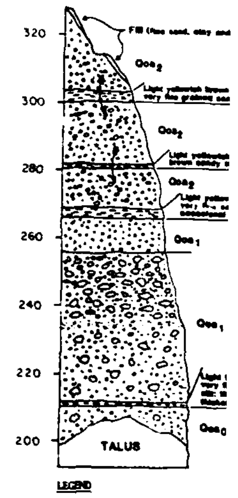


STRATIGRAPHIC COLUMN 2
CENTRAL PIT



STRATIGRAPHIC COLUMN 3
SOUTH PIT

BOND PIT



LEGEND

Qoa_0 - Yellowish gray brown san
clasts. Matrix is silty
slight to moderate cemen

Qoa_1 - Light reddish to yellowi
> 10", 30% 2" - 4", 30%
fine to coarse grained.

Qoa_2 - Grey brown sandy gravel:
50% ¼" - 2"; subgranular
to coarse gravelly sand.

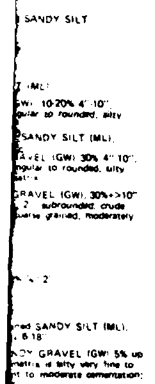
GENERALIZED STRA

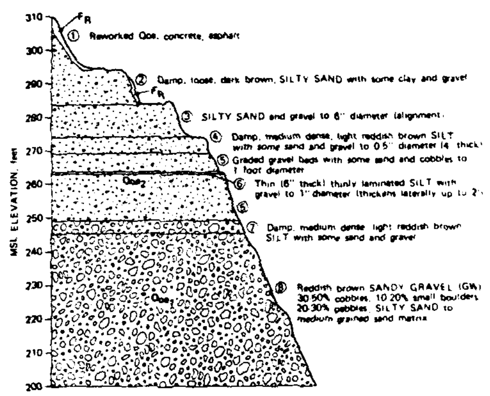
S

LEGEND FOR STRATIGRAPHIC COLUMNS 2, 3, 4, AND 5

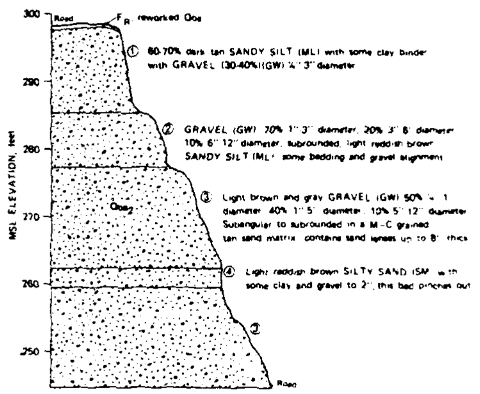
Qoa2 — Older Alluvium: Gray brown to brownish gray Sand and Gravel (GW), 30 to 40% small cobbles; 50% very coarse pebbles, occasional boulders; medium to coarse grained Sand matrix; some Sandy Silt (ML) beds up to 3 feet thick

Qoa1 — Older Alluvium: Brown Sandy Gravel (GW), 20 to 30% small boulders, 30 to 50% small to large cobbles, and 20 to 30% pebbles. Silty fine to medium grained Sand matrix; some reddish brown Sandy Silt (ML) beds to 5 feet thick



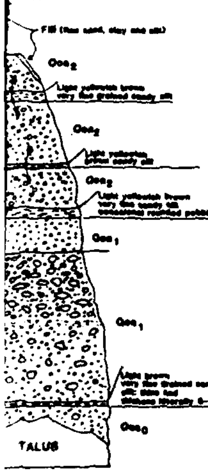


STRATIGRAPHIC COLUMN 4
NORTHEAST SIDE OF SOUTH PIT

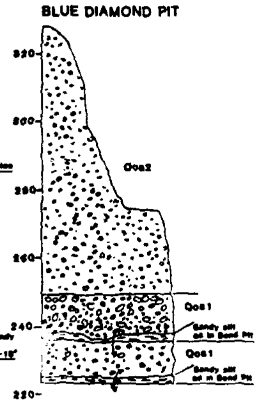


STRATIGRAPHIC COLUMN 5
SOUTH CORNER OF SOUTH PIT

D PIT



BLUE DIAMOND PIT



NOTES

1. STRATIGRAPHIC COLUMNS 2, 3, 4, AND 5 WERE DEVELOPED BY WOODWARD-CLYDE CONSULTANTS
2. "GENERALIZED STRATIGRAPHIC COLUMNS AT THE BASINS" WERE DEVELOPED BY PLANNING RESEARCH CORPORATION (PRC) ENGINEERING

D

- Yellowish gray brown sandy gravel; 5% up to 10", ½" to 5", clasts. Matrix is silty very fine to fine grained sand, slight to moderate cementation; interlocking clasts.
- Light reddish to yellowish gray sandy gravel; 20 - 40% > 10", 30% 2" - 4", 30% ½" - 2"; subrounded. Matrix is silty fine to coarse grained, moderately cemented, interlocking clasts.
- Gray brown sandy gravel; 10 - 20% 4" - 10", 30% 2" - 4", 50% ½" - 2"; subangular to subrounded. Matrix is medium to coarse gravelly sand.

GENERALIZED STRATIGRAPHIC COLUMNS AT THE BASINS

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK
BOND AND BLUE DIAMOND GRAVEL PITS

STRATIGRAPHIC COLUMNS
DEVELOPED BY WOODWARD-CLYDE CONSULTANTS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

COUNTY OF ORANGE
ENVIRONMENTAL MANAGEMENT AGENCY
BORING LOG

Sheet ___ of ___

PROJECT Santiago Gravel Pit LOCATION Bond St. Gravel Pit
BORING Nº 1 SURF. ELEV. 300± LOGGED BY S.S.&J.D. DATE 1-21-7[illegible]

Sample Nº Field	Lab.	Depth	Log	Remarks
				Lt. Brn. Silty Very Fine Sand - Loose-Dry
		5'		Lt. Brn. Silty Very Fine Sand - Loose-Slighty Damp
		10'		Lt. Brn. Silty Very Fine Sand - Loose-Damp (with tr. clay)
		14'		
		15'		Lt. Brn. Clayey, Silty Very Fine Sand - Loose-Damp
		20'		Lt. Brn. Clayey, Silty Very Fine Sand - Loose-Wet
		22½'		Med. Brn., Very, Very Fine Sandy, Silty Clay - Loose Very Wet.
		25'		Med. Brn. Very, Very Fine Sandy, Silty Clay Loose - Very Wet.
		27½'		Med. Brn. Very Fine Sandy Silty Clay - Loose - Very Wet
		30'		Med. Reddish Brn., Very Fine Sandy, Silty Clay - Loose - Very Wet.
		35'		Med. Brn., Very Fine Sand, Clayey Silt Loose - Extremely Wet.

COUNTY OF ORANGE
ENVIRONMENTAL MANAGEMENT AGENCY
BORING LOG

Sheet 1 of 1

PROJECT Santiago Gravel Pit LOCATION Bond St. Pit
BORING Nº 2 SURF ELEV ___ LOGGED BY S.S&J.D. DATE 1-[illegible]

Sample Nº Field	Lab.	Depth	Log	Remarks
				Gravelly Sand up to 9" Dia. - (up to 9" Dia. Cobbles Encountered) Firm - Slightly Damp.
		5'		
		10'		Brn., Silty Sand & Gravel with Cobbles up to 9" Dia. Firm-Damp.
		15'		
		18'		Brn. Silty Sand & Gravel - Firm-Wet
		20'		Brn. Silty Sand & Gravel - Firm-Very Wet
		25'		
		27'		Reddish Brn. Silty, Clayey Sand & Gravel - Firm - Extremely Wet.
		28'		
				Bottom of boring, large boulders on top of clay and water

COUNTY OF ORANGE
ENVIRONMENTAL MANAGEMENT AGENCY
BORING LOG

PROJECT Santiago Gravel Pit LOCATION Bond St. Gr
BORING Nº 3 SURF. ELEV ___ LOGGED BY J.D.

Sample Nº Field	Lab.	Depth	Log	Remarks
				Reddish Brn. Silty Sand & Gravel - Firm - Slightl with Cobbles up to 9" in Dia.
		5'		
		10'		
		15'		Bottom of Hole

COUNTY OF ORANGE
ENVIRONMENTAL MANAGEMENT AGENCY
BORING LOG

PROJECT Bond St. Gravel Pit LOCATION Bond St. Pit
BORING Nº 4 SURF ELEV ___ LOGGED BY J.D.

Sample Nº Field	Lab	Depth	Log	Remarks
				Brn. gravel & Cobbles up to 1' in D (Small amount of Silty Sand) - Firm
		5'		
		8'		Bottom of Hole Boulders too large t

COUNTY OF ORANGE
ENVIRONMENTAL MANAGEMENT AGENCY
BORING LOG

PROJECT Santiago Gravel Pit LOCATION Bond St.
BORING Nº 5 SURF ELEV ___ LOGGED BY J.D.

Sample Nº Field	Lab	Depth	Log	Remarks
				Reddish Brn Silty Sand, Gravel & Co Slightly Moist.
		5'		
		10'		Bottom of Hole Boulders to large

E ENGINEERING PAYS

COUNTY OF ORANGE — Sheet 1 of 1
ENVIRONMENTAL MANAGEMENT AGENCY
BORING LOG

PROJECT: Santiago Gravel Pit — LOCATION: Bond St. Gravel Pit
BORING No: 6 — SURF. ELEV: — LOGGED BY: J.D. — DATE: 1-22-76

Sample No. Field	Sample No. Lab.	Depth	Log	Remarks
				Reddish Brn. Silty Sand & gravel with Cobbles - Firm - slightly Moist.
		5'		
		10'		
		15		Reddish Brn. Clayey, Silty, Sand & Gravel with Cobbles - Firm-Wet
		20'		Reddish Brn., Clayey Silty Sand & Gravel with Cobbles - Firm-Very Wet.
		25'		Bottom of Hole Large Cobbles also Perched Water.

COUNTY OF ORANGE — Sheet 1 of 1
ENVIRONMENTAL MANAGEMENT AGENCY
BORING LOG

PROJECT: Santiago Gravel Pit — LOCATION: Bond St. Gravel Pit
BORING No: 7 — SURF. ELEV: — LOGGED BY: J.D. — DATE: 1-2?-76

Sample No. Field	Sample No. Lab.	Depth	Log	Remarks
				Reddish Brn. Silty Sand, Gravel - Cobbles Firm-Dry
		5'		Bottom of Hole Cobbles too big - tried 5 locations in Area - Could not go deeper than 5 feet.

COUNTY OF ORANGE — Sheet 1 of 1
ENVIRONMENTAL MANAGEMENT AGENCY
BORING LOG

PROJECT: Santaigo Gravel Pit — LOCATION: Bond St. Gravel Pit
BORING No: 8 — SURF. ELEV: J.D. — LOGGED BY: — DATE: 2-1-[illegible]

Sample No. Field	Sample No. Lab.	Depth	Log	Remarks
				Med. Brn., Clayey, Very Fine Silty Sand - Firm - Moist
		5'		
		10'		
		15'		
		20'		
		25'		
				Med. Brn. Clayey Fine Sand Silt (with gravel) Firm - Moist
		30'		
				Med. Brn., Clayey, Very Fine Silty Sand - Firm - moist.
		35'		35' - 50'
		50'		Med. Brn., Clayey Fine Sandy Silt (with gravel) Firm - Moist.

SAFETY PAYS

SANTA ANA RIVER BASIN, CALIFORNIA
SANTA ANA RIVER MAIN STEM (INCLUDING SANTIAGO CREEK)

SANTIAGO CREEK
BOND AND BLUE DIAMOND GRAVEL PITS

BORING LOGS
BORING NO. 1 TO 8 (B-1 TO B-8)

DEVELOPED BY ORANGE COUNTY
ENVIRONMENTAL MANAGEMENT AGENCY

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

B RECREATION

RECREATION APPENDIX B

PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER

SANTIAGO CREEK

County of Orange

Cities of Santa Ana

and Orange, California

U.S. ARMY ENGINEERING DISTRICT

LOS ANGELES, CALIFORNIA

AUGUST 1988

CONTENTS

Contents (Continued)

Tables

Plates

Attachments

I. INTRODUCTION

1-01 This appendix details the background, authority, purpose, scope, and assumptions for the development of recreation features for the Santiago Creek project.

Background and Authority

1-02 A "Review Report for Flood Control, Santa Ana River, Mainstem", dated December 1975, was prepared by the Los Angeles District, Corps of Engineers. It presented a plan of trails and other recreation facilities to be developed with the proposed Santa Ana River Mainstem flood control project.

1-03 Subsequent to the Review Report was the preparation of the Phase I General Design Memorandum. The purpose of the Phase I General Design Memorandum was to examine the 1975 Review Report and to affirm the validity of the previously proposed plan in light of current conditions and criteria, or to reformulate the plan as required by such conditions and criteria. Nearly 5 years had elapsed since the Survey Report study conclusions had been made.

1-04 The initial study of recreation potential for the Santa Ana River Mainstem, Santiago Creek, and Oak Street Drain was authorized by the Federal Water Project Act of 1965, and as required by the Federal Water Project Recreation Act of 1965, Public Law 89-72, whereby full consideration must be given to the opportunities for public outdoor recreation afforded by the water resource development project. The Water Resource Development Act of 1976, Section 109, authorized the Phase I advanced engineering and design for the Santa Ana River Project. The Phase I General Design Memorandum, including recreation as a project purpose was submitted in September 1980, and approved in January 1982. The recommended plan for recreation development proposed for the Santa Ana River Mainstem and Santiago Creek was found to be economically justified and desirable. Authorization for construction of the Santa Ana River Mainstem Project, including Santiago Creek, was contained in the Water Resource Development Act of 1986.

Purpose

1-05 The purpose of this appendix is to identify the recreational and environmental resources along Santiago Creek of the Santa Ana River Flood Control Project, present public use projections, and show the level of recreational development appropriate to accommodate the anticipated use. The appendix will also serve as a general guide to the orderly and coordinated development and management of the environmental resources of the project lands. Cost estimates for the proposed recreation facilities are provided. The Santiago Creek flood control plan was developed in accordance with the overall Santa Ana River Flood Control project, which has been authorized as a local protection project and as a result no Master Plan will be prepared. The information contained in the Phase II General Design Memorandum is considered sufficient for the preparation of plans and specifications.

Scope

1-06 This appendix is limited to specific information required to ensure an understanding of the basic recreational and environmental resources inherent within the Santiago Creek Flood Control Project. The information provided consists of the demographic characteristics of the project area; topographical, geological and ecological features; a narrative description of existing and proposed recreational facilities, market area analysis, projected development costs, and coordination activities involving other agencies. The intent of this appendix is to present a plan for the public use of project lands that is compatible with the preservation of existing environmental resources.

Basic Assumptions

1-07 Corps participation along Santiago Creek for recreation improvements is limited to lands acquired for flood control purposes. Acquisitions or improvements required outside these limits will be the responsibility of the local sponsor. Flood control improvements by the Corps, are being developed for Reach 1, between the Santa Ana River confluence and the Santa Ana Freeway, and for Reach 3, between Walnut Street and Prospect Road.

1-08 The recreation plan for Santiago Creek was developed in conjunction with the Lower Santa Ana River recreation plan in order to maintain continuity of the completed mainstem recreation system. A description of the mainstem system is contained in Volume 6 of this report. All features will be designed in an efficient and economic manner to reduce operation and maintenance costs.

1-09 The Environmental Management Agency (EMA) of the County of Orange is implementing their master plan of countywide bikeways. This plan was originally adopted by the Orange County Board of Supervisors on September 29, 1971 as a component of the recreation element of Orange

County's General Plan, and on September 23, 1980 ratified as a component of the transportation element of the general plan. In conjunction with this plan the cities of Santa Ana and Orange have also developed bike trail networks within their city limits. Local city bicycle routes would make connection to the regional trails at either end of the proposed trail. The proposed Santiago Creek bicycle trail would provide an important segment or link to the overall regional trail network. In addition, a trail rest stop has been proposed off Hewes Road that would overlook the pits (pl. 2). The plan recommended in this appendix is in general accordance with the EMA master plan of countywide bikeways. Local funds will be available for development of both facilities from EMA, the local sponsor for Santiago Creek.

II. DESCRIPTION OF PROJECT AREA

2-01 A comprehensive description of the project area is included in the Environmental Impact Statement. Project area features covered in this section are pertinent only to the formulation of the recreation plan.

2-02 Santiago Creek (plate 1) the largest tributary of the Santa Ana River in Orange County, flows in a westerly course from its headwaters in the Santa Ana Mountains through the cities of Orange and Santa Ana to its confluence with the Santa Ana River in the city of Santa Ana just south of the Garden Grove Freeway (State Highway 22). The creeks width varies within the 6.9 mile long project area between Villa Park Road and the Santa Ana River. The upstream reach is wide open and contains sand and gravel operations, while the downstream reach from Chapman Avenue is narrow and has been reduced in width by urban development.

Biological and Ecological Features and Resources

2-03 Santiago Creek above Villa Park Road contains native and riparian vegetation. The pit area contains ponded water following rains which attract several bird species. The most significant vegetative habitat, within this area is a grove of willows. Due to the sensitivity of this existing habitat, U.S. Fish and Wildlife has placed development restrictions within and adjacent to this area of the pits as part of their mitigation plan for this project. Therefore, no recreational features will be constructed within the pits themselves as proposed in the Phase I GDM plan. Fencing by itself would not completely prevent human penetration of the area, only discourage it.

2-04 Pursuant to U.S. Fish and Wildlife restrictions, the portion of proposed bike trail located on a graded bench within the pits (Phase I GDM) along the east and west sides of the Bond Avenue gravel pits has been relocated outside the fenced pit area onto the graded perimeter surface area. The remaining portion below Prospect Avenue is unchanged. No significant biological resources will be affected by its presence. The rest stop located adjacent to Hewes Street (pl. B-2) provides an excellent recreation as well as educational experience of wildlife and vegetation in an urbanized environment. Its placement avoids any possible impact inside the pits.

2-05 Downstream of Prospect Avenue patches of riparian growth are found. The bike trail runs adjacent to the creek on top of the levee down to the Walnut Avenue. From here to the Santa Ana River confluence many trees, shrubs, and ground cover species grow along side slopes of the channel. Local city bicycle routes would connect to the trail at Walnut Avenue, to connect the regional trail system to the furthest downstream end of the project (pl. B-2).

Climate

2-06 The climate is mediterranean in nature; mild winters and hot summers. Dry, seasonal winds called the "Santa Anas", come from the desert areas to the northeast and east. Annual precipitation averages 12 inches per year, with 92 percent of it falling between November and April.

2-07 Climate conditions in the immediate coastal area are directly influenced by the surrounding marine air conditions which produce moderate to hot summers and mild winters. There is moderate to heavy fog occurring primarily from mid-December to March. Low clouds are mainly restricted to the late afternoon to mid-mornings.

Topography

2-08 The topography within the project boundary is relatively flat with a gradient suited for a bicycle trail. Elevations vary from approximately 300 feet at Prospect Avenue in the pit area to approximately 110 feet at the confluence, a distance of 5.7 miles. The creek is located on a semi-natural coastal flood plain which has been reduced considerably by local encroaching development. Santiago Creek has a rich source of sand and gravel. It is characterized as being generally narrow and stony rugged, with the bottom natural except in two parks, Santiago and Hart, where concrete channels are used for parking lots.

Geology and Soil Characteristics

2-09 The coastal plain, a physiographic and structural basin, contains a thick sequence (up to 30,000 feet) of chiefly marine and non-marine clastic sedimentary rocks overlying igneous and metamorphic basement rocks. These sediments, derived from surrounding highland areas, were deposited in the ever deepening basin; an ongoing process which during the most recent geologic time has resulted in the accumulation of up to several hundred feet of alluvium in modern stream channels and associated floodplains and alluvial fans, and beaches.

Access and Circulation

2-10 The urbanized section of lower Santiago Creek, between the Santa Ana River and Prospect Avenue, is crossed by many arterial roads as well as three freeways (Garden Grove, Santa Ana, Newport). Access to the proposed bicycle trail would be limited to Walnut Street and Prospect Avenue. Access to the trail rest stop would be only off Hewes Road (pl. B-2).

2-11 Due to the dense urbanization of the area, arterial roads are subject to extremely heavy and hazardous traffic conditions, that discourage their use by most bikers. The proposed bike trail would provide a safe transporation corridor through this area and encourage increased use of the Santa Ana River Regional Bike Trail.

Operational Limitations

2-12 Development of the Santiago Creek equestrian trail has been dropped from the recreation plan due to the lack of interest and support from local agencies and the community.

2-13 No recreational development will occur within the 240 acre "Bond Pit" as proposed in the Phase I General Design Memorandum document because of U.S. Fish and Wildlife environmental restrictions. The trail rest stop off Hewes Road does not interfere with flood control or water conservation operations within the pits or with U.S. Fish and Wildlife environmental constraints.

III. RECREATION MARKET AREA

Boundaries/Region Served

3-01 The recreation market area for the proposed Santiago Creek Flood Control Project consists of an area of approximately 2 miles from the creek's centerline, from Villa Park Road to the Santa Ana River. This area was choosen because it was considered to be a reasonable distance for recreationists to travel to use the proposed bike trail and rest stop. It is anticipated that a minimum of 80 percent of the day use of the proposed facilities would originate within this zone. Additional usage from outside the market area is also anticipated, because the trail would serve as a link between the Santa Ana River Regional Bike Trail and the counties proposed regional bike route, upstream at Weir Canyon Road. Market area and demand have been analyzed for the entire Santiago Creek trail corridor since the Corps development would be an integral part of the proposed trail system under development by local agencies.

Socio-Economic Characteristics

3-02 Users of the trail are anticipated to come primarily from the cities of Santa Ana, Orange, and Villa Park. The Southern California Association of Government's data shows these three communities to be in Regional Statistical Area (RSA) 42, Greater Santa Ana. Based on their data a reasonable estimate for the total population of this RSA as of 1980 was 377,316. Projected populations are shown on the table below. Approximately 1/2 of the heavily populated areas within the RSA are within the 2-mile service radius of Santiago Creek. According to the U.S. Bureau of Census it estimated the uncounted population to be about 2.5 percent. The figures reflected in this appendix do not account for these persons.

Table B-1. Projected Population in Santiago Creek Market Area. 1980-2000[1]

1980	1985	1990	1995	2000
377,316	412,500	437,200	453,100	462,400

[1]Based on Southern California Association of Government Data and Orange County Preferred Projections; 1985 (Orange County Department of Administration-Forecast and Analysis Center).

3-03 The majority of residents of this area are young to middle age, with incomes ranging from moderate to high. In 1980, there were 207,023 workers employed in the area. The percentage of athletically oriented adults and bicycle riding children is higher than average in the county.

Inventory of Existing and Proposed Facilities

3-04 At this time there are no Class I bicycle trails (trails completely separate from motorized traffic) within the market area. The Santa Ana River Regional Bike Trail, which parallels the Santa Ana River, is heavily used, but would not compete with the Santiago Creek bicycle trail. The Santiago Creek project would provide convenient access to the proposed Santa Ana River regional trail system. It would establish a link between recreational facilities along the Santa Ana River and local parks and communities along the course of Santiago Creek. The proposed project would make efficient use of the channel right-of-way and encourage alternate transportation modes within the urban area. The project would help reduce deficiencies of trail facilities in the market area. Local agencies are encouraging private developers along the creek to complete segments of the trail as conditions for acquiring their necessary permits.

3-05 Future development of bicycle trails in the local area would consist of completing the remaining miles of bike trail, by the local agencies, along Santiago Creek, as well as completion of the connection link via Weir Canyon, up to Weir Canyon Road to the Santa Ana River regional trail.

3-06 Demand for recreational activities proposed for Santiago Creek is based upon the application of per capita participation rates to the market area population 5 years of age and older. The recreation market area had a trail demand for over 2.2 million activity days during peak summer months in 1985 and will have over 4.5 million activity days during peak summer months in the year 2000. This is based upon summer season per capita participation rates provided in the Orange County Recreation Needs and Regional Park Study and is shown below:

Table B-2. Potential Trail Demand for Santiago Creek Market Area for Summer Season[1]. 1985 and 2000

	Per Capita Participation Rates[2]		Market Area	
	1985	2000	1985	2000
Population				
Five Years of Age & Over (thousands)[3]	NA	NA	183,562	208,080
Activity:				
Bicycling	12.15	21.50	2,230,278	4,473,720
Total Trail Demand			2,413,840	4,681,800

[1]Memorial Day through Labor Day
[2]For Population Over Five Years of Age and Older
[3]89 percent of Total Population in 1985, 90 percent in 2000

3-07 The Santiago Creek trail could accommodate approximately 2 percent of trail market demand in 1985 and 1 percent of demand in 2000. This is based upon a maximum peak season use of 48,708 shown in the following table B-3.

Table B-3. Maximum Use During Peak Summer Season for Santiago Creek Trails.

Activity	Density x	Units x	Turn Over x	Duplication Ratio =	# of Max Daily Recreation Days x	Weekend Days In Peak Month =	Total Weekend Use In Peak Month ÷	% of Peak Use On Weekend =	Total Use During Peak x	# of Peak Months In Summer Season Month =	Total Use During Peak Season
Bicycling	20	8.2	5	1	820	9	7,380	.5	14,760	3.3	48,708

IV. RESOURCE USE OBJECTIVES

Definition

4-01 Resource use objectives complement the description of the project area and the analysis of the recreation market area. The objectives state the scope and intent of the overall planning objectives within which the proposed plan of physical development was formulated. The objectives also outline the plan for optimum use of project lands and resources.

4-02 Several local strip parks, operated by the Cities of Santa Ana and Orange, and a natural park at the base of the Villa Park Dam, operated by Orange County, are located along the course of Santiago Creek from Villa Park Dam to the Santa Ana River. Although this reach of the creek is primarily surrounded by urban areas, there are some large gravel pit mining operations along the creek, north of Bond Avenue. These pits are a part of the recommended flood control system as a detention basin.

Basic Objectives

4-03 The basic objectives are outlined below:

a. To provide a high quality experience for bicycling and hiking opportunities through a well-planned trail system;

b. To maximize the use of flood control rights-of-way and improvements for park and recreational trail activities;

c. To expand recreational trail opportunities by providing linkages to the Santa Ana River and Santiago Oaks Regional Park;

d. To locate trails and ancillary facilities with respect to resources sensitive to human use;

e. To limit incompatible development. Trails would be built in a manner which is in harmony with adjacent uses. Landscaping would provide shade, screening and general esthetic treatment to benefit both the trail users and adjacent land users. Architectural standards on structures and signage would create consistency of appearance of any structures to be built within the project area.

Resource Use Objectives

4-04 Objective 1: To provide a scenic, safe, high quality bicycle trail that would function, and serve as an integral component of the 8.2 mile Santiago Creek Bicycle Trail.

(Discussion) There is a strong demand for bicycle trails along Santiago Creek. No Class I trails currently exist within the cities of Santa Ana and Orange along the creek. The County of Orange has indicated that development of a countywide bikeway system would provide both recreation and commuter bicyclists access to key areas within the county. The levee top along which the trail would run, provides a key segment in this integrated system. The City of Orange has begun efforts to get private developers to construct parts of the trail as a condition for permit acquistion. Increased urbanization of the lands surrounding the flood control project would provide a high user rate for the bicycle trail. With the trails gradient suited for bicycle users, a more enjoyable experience will be provided.

4-05 Objective 2: To develop an erosion control and esthetic treatment plan to complement the flood control project.

(Discussion) Construction of the flood control channel would disrupt the surrounding natural environment. Vegetation provided for erosion control and esthetic treatment would be compatible with the existing native vegetation located within immediate surroundings, thereby maintaining the identity and character of that particular area.

V. RECOMMENDED PLAN OF PHYSICAL DEVELOPMENT

5-01 The proposed flood control project would provide adequate space within the project right-of-way for construction of a 12-foot-wide, 1.7-mile bicycle trail (pls. 2 and 3). The 12-foot-wide bicycle trail is proposed because the local sponsor, the County of Orange is required to comply with the guidelines established by the California Department of Transportation (CALTRANS) for high density CLASS I bicycle trails in urban areas. The bicycle trail would run upstream from Walnut Avenue to Prospect Street, a distance of .7 miles, on the maintenance road on the east bank of Santiago Creek. The maintenance road along this reach of channel would be constructed and paved as a part of the basic flood control project. In light of this, no costs are reflected in the recreation accounts (table B-4 and page 7, Exhibit A). The bicycle trail above Prospect Street to the proposed rest stop, a distance of 1 mile, would be located within the project right-of-way on the east side of the Band Pit. This reach would be paved as a part of the recreation project, and cost shared on a 50-50 basis with the local sponsor. The trail would be primarily for recreational bicycling but would also accommodate hikers and joggers, as well as fulfill a local transportation need. The trail would serve as an integral component of the Countywide Bikeway Plan and also provide a direct east-west transportation corridor between the Santa Ana River Bicycle Trail and the proposed Weir Canyon Road Regional Trail (pl. 3).

5-02 The proposed trail rest stop (pl. 4) would be located on the west side of Hewes Road, overlooking the pits, but set back approximately 10-15 feet from the top of the pits side slope. The rest stop would be accessible from a Class I bike trail, that follows the outside perimeter fence of the pit area, after exiting the Class I trail at Prospect Avenue via an undercrossing built at locals expense. A proposed County regional park is slated for development on the opposite side of Hewes Road from the trail rest stop. Originally designated in the Phase I report as a staging area between Walnut and Prospect, the county now supports downgrading the facility to a rest stop in addition to relocating it closer to their county regional park location for operation and maintenance purposes. The county would be the local cost-sharing agency for development and maintenance of the rest stop, which would be approximately 200 ft^2, with some parking and would include site amenities such as fencing, benches, fountain, trash receptacles and display board. Restroom facilities are currently available at Yorba Park, approximately 2 miles downstream, and at Santiago Oaks Regional Park, approximately 2.2 miles upstream. Restroom facilities will also be available at the Regional Park proposed for development directly adjacent to the rest stop. In light of the above, no restroom facilities would be provided at the rest stop.

VI. COORDINATION WITH OTHER AGENCIES

6-01 The following Federal, State, County, and local agencies have been contacted. The roles they played in the planning and coordination of the proposed plan are briefly summarized.

Federal Agencies

6-02 The Department of the Interior, U.S. Fish and Wildlife Service. Coordination with this agency was to evaluate and provide mitigation areas for plant and wildlife habitat. Their concerns centered on the routing of the proposed bike trail within the pits right-of-way (ROW). Because of the sensitive ecological areas, the trails have been removed from within the pit area and have been routed outside the area to discourage unauthorized use and to protect habitat from human penetration. Because of the extreme sensitivity of an established willow habitat within the pits, proposed recreation within the pit area (Phase 1 GDM) has been removed.

State Agencies

6-03 California State Parks and Recreation Department was contacted for information regarding general recreation planning data for southern California.

County Agencies

6-04 The County of Orange, Department of Parks and Recreation, Transportation Planning Division and the Department of Administration-Forecast and Analysis Center. Coordination was conducted with the Department of Parks and Recreation and the Transportation Planning Division concerning development of the bike trail and rest stop as a cost-shared venture, with the county operating and maintaining facilities upon completion of there construction. Demographic information was supplied by the Department of Administration.

Local Groups

6-05 Cities of Santa Ana and Orange. Coordination was conducted with park planning and public work agency representatives on several occasions to review local policies, plans, and programs for an integrated recreational trail and regional park concept along Santiago Creek.

6-06 Orange County Water District. Coordination was conducted with this agency regarding recreational development concepts for the pit area.

Special Problems

6-07 In the event that locally proposed Class I and II bike trail connections at both ends of the project are not constructed, the result would be a break in the continuous Santiago Creek Bike Trail System, as well as, a missing link to the counties bikeway master plan. The plan as proposed within this document would not create any serious environmental problems. If the above mentioned situation should arise, the demand for trails and the rapid growth of population within this general geographic area, would in and of itself justify construction of the cost shared portion of trail. Local implementation of the plan is dependent on available funding.

VII. MANAGEMENT AND COST SHARING

7-01 The operation and management of all recreation facilities constructed under this authority would be the responsibility of the County of Orange.

7-02 The Corps of Engineers' reponsibilities are set forth in Section 1 of the Flood Control Act of 1944 and in the DAEN-CWP-DAEN-CWO-R Principles Governing Financial Participation by the Corps of Engineers in Recreation Development of Local Flood Control Projects. Construction costs for recreational development would be cost shared on a 50-50 basis between the local agency and the Federal Government. If needs change later, and the acquisition of additional land for recreation is necessary, the acquisition will be the local sponsor's responsibility. The paved access road along the south side of the creek between Walnut and Prospect is a feature of the flood control project and will double as a bike trail. Therefore, no paving costs will be charged to recreation in the development of this segment of the bike trail.

VIII. ENVIRONMENTAL QUALITY

Channelization improvements along Santiago Creek would result in the removal of a significant amount of existing vegetation. Being located in a densely populated area the project will be highly visible. In order to lessen the stark visual impact of the project, landscaping will be provided prior to completion of construction. In addition, the landscaping would provide for erosion control, and develop bank stabilization. A discussion of the recommended landscape and erosion control plan is provided in the General Design Memorandum.

IX. COSTS

General

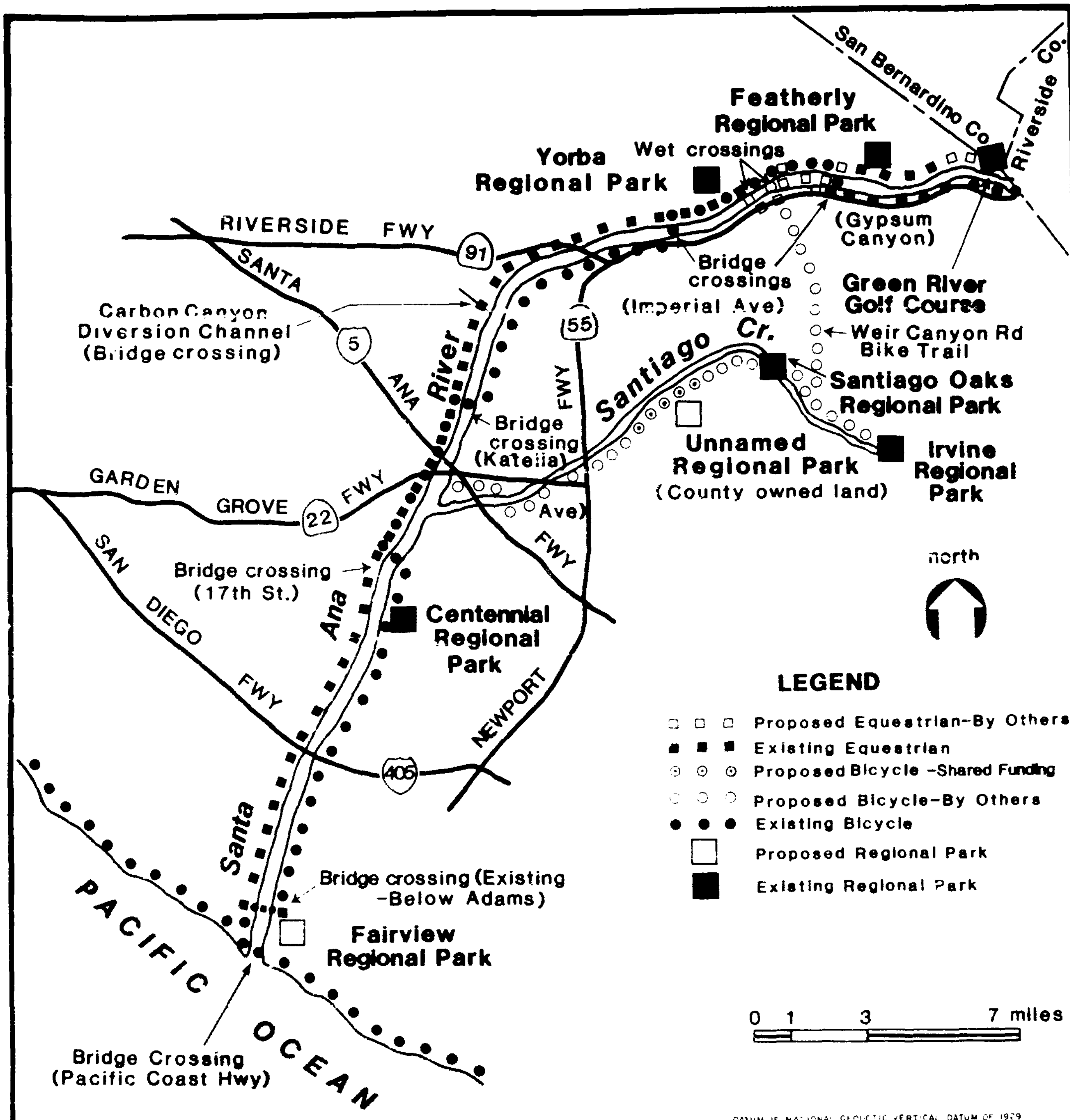
9-01 All separable costs attributed to recreation will be cost shared on a 50-50 basis with local interests. The bicycle trail and trail rest stop will be constructed concurrent to the flood control project.

Cost Summary and Estimate

9-02 A detailed cost estimate for the proposed bicycle trail and rest stop is presented in table 4.

Table B-4. Recreational Development Cost Estimate.

Description	Quantity	Unit	Unit Cost	Totals
BICYCLE TRAIL				
Bicycle Trail	5280	LF	16.90	89,232.00
Signs (Entrance Directional)	2	EA	500.00	1,000.00
Traffic Control Signs	2	EA	500.00	1,000.00
Gates	2	EA	500.00	1,000.00
REST STOP				
Concrete Wheel Stops 6"x10"x6'	4	EA	25.00	100.00
A.C. Parking	2,250	SF	3.50	7,875.00
Curbing	176	LF	3.00	528.00
Concrete Walk (5'x20')	100	SF	2.00	200.00
Overlook Shelter (15'x18')	1	EA	25,000.00	25,000.00
Fountain	1	EA	1,200.00	1,200.00
Tree Planting	17	EA	70.00	1,190.00
Shrub Planting	20	EA	35.00	700.00
Trash Receptacles	4	EA	300.00	1,200.00
Benches	4	EA	100.00	400.00
Entrance Signs	2	EA	500.00	1,000.00
Display Boards	3	EA	800.00	2,400.00
Drip Irrigation System	1	LS	3,300.00	3,330.00
90 Days Maintenance and Plant Establish Period	1	LS	5,500.00	5,500.00
Seeding w/Soil Prep. and and Amend.	1	LS	2,500.00	2,500.00
Subtotal				$145,355.00
Contingencies (15%)				21,803.00
Subtotal				$167,158.00
Engineering and Design (10%)				16,715.00
Supervision and Administration (6%)				10,029.00
TOTAL RECREATION				$193,902.00
50% Share of Recreation Cost				$96,951.00



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

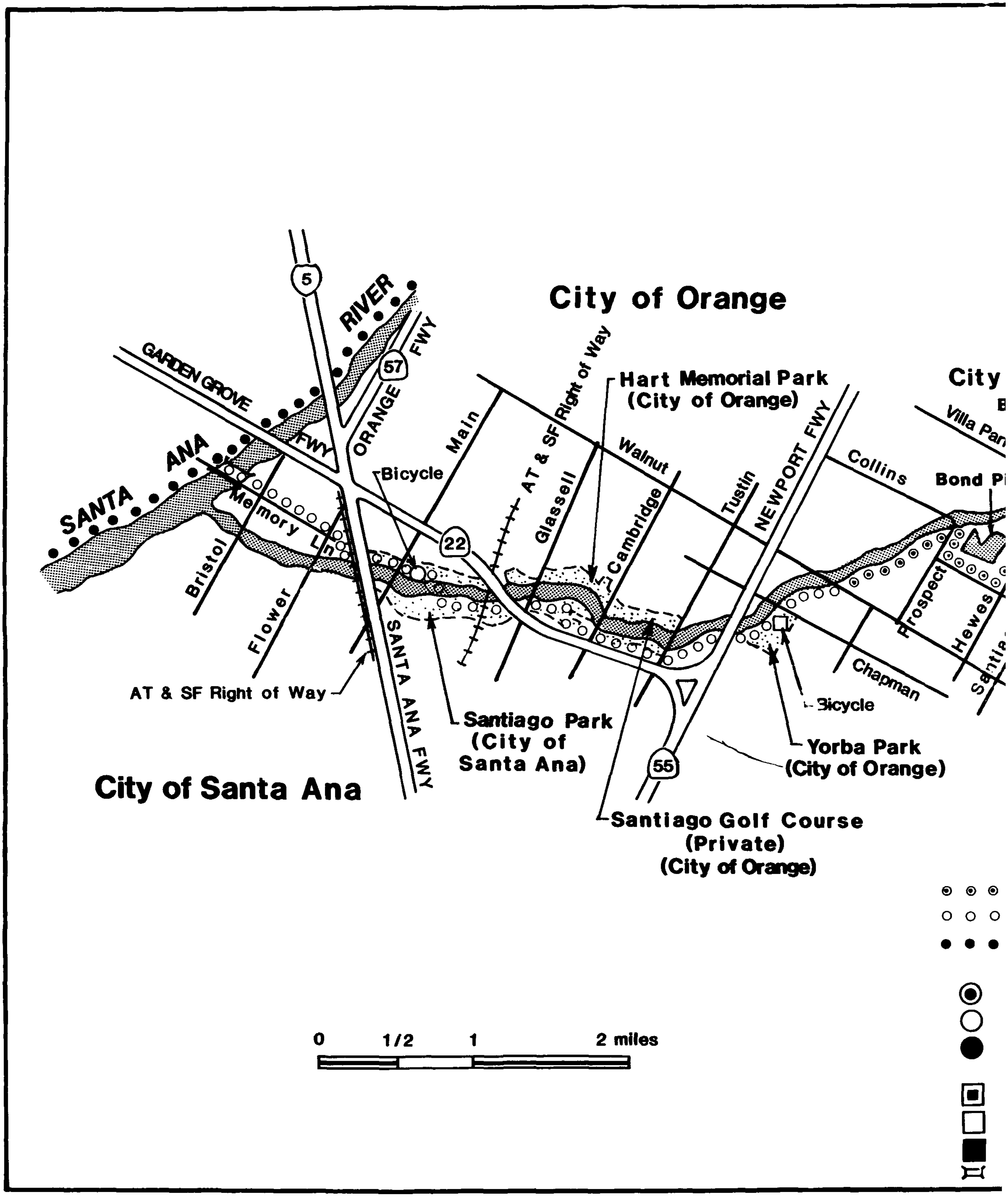
DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET OF SHEETS
DISTRICT FILE NO.

PLATE B-1



City of Orange
City of Santa Ana
SANTA ANA RIVER
GARDEN GROVE FWY
ORANGE FWY
SANTA ANA FWY
NEWPORT FWY
5
57
22
55
Memory Ln
Bristol
Flower
Main
Glassell
Cambridge
Tustin
Walnut
Collins
Chapman
Prospect
Hewes
Villa Park
Bicycle
AT & SF Right of Way
Hart Memorial Park
(City of Orange)
Santiago Park
(City of
Santa Ana)
Yorba Park
(City of Orange)
Santiago Golf Course
(Private)
(City of Orange)
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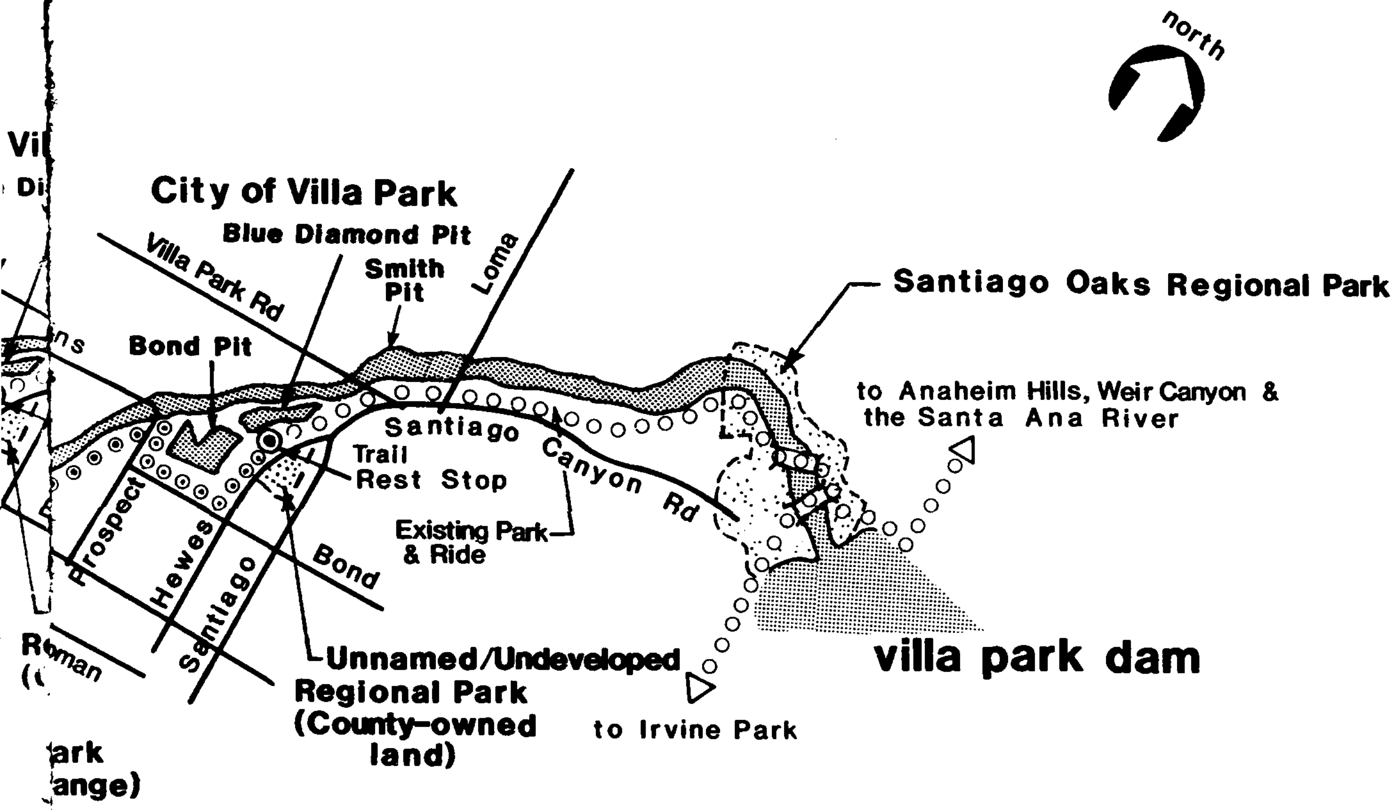


LEGEND

Bicycle Trails

- ◎ ◎ ◎ Proposed–Shared Funding
- ○ ○ ○ Proposed–Regional–by others
- ● ● ● Existing

Rest Stops

- Shared Funding
- Regional–by others
- Existing

Staging Areas

- Shared Funding
- Regional–by others
- Existing
- Bridge

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY. | DRAWN BY. | CHECKED BY.

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

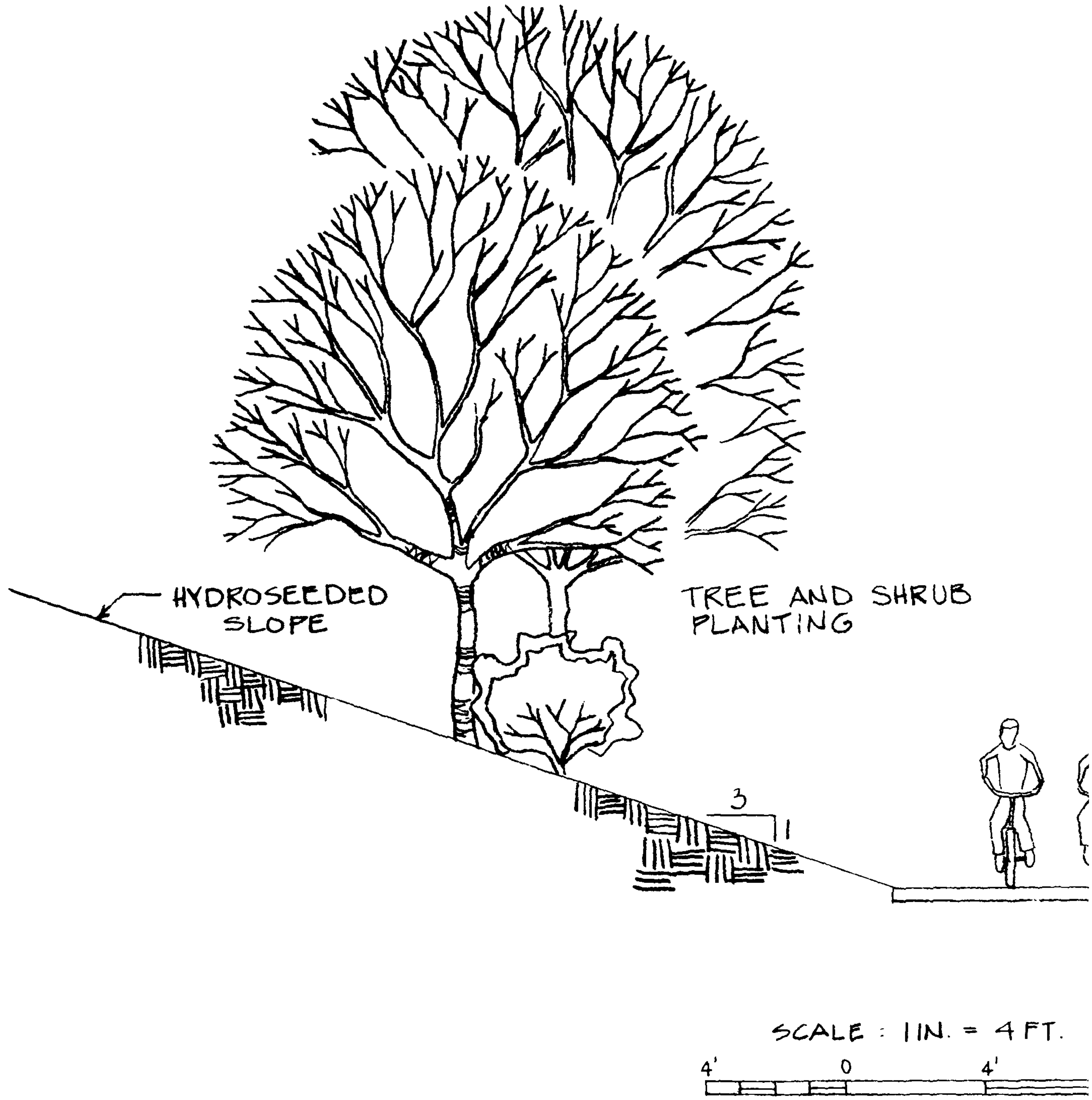
SANTIAGO CREEK CHANNEL

RECREATION TRAIL PLAN

SUBMITTED BY. | DATE APPROVED. | SPEC. NO. DACW09-____ B-____ | SHEET OF SHEETS

DISTRICT FILE NO.

PLATE B-2



HYDROSEEDED SLOPE
TREE AND SHRUB PLANTING
3
1
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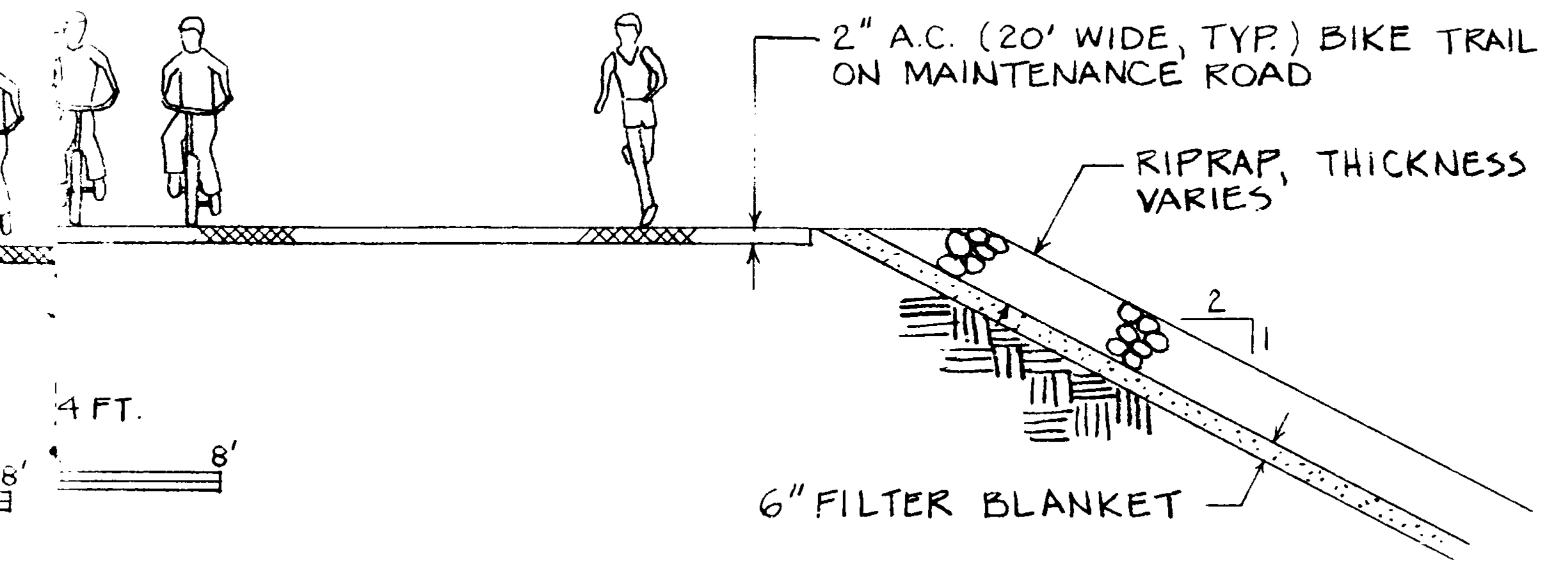
4'
0
4'



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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL

DRAWN BY: EBL

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL

TYPICAL SECTION OF BIKE TRAIL

SUBMITTED BY:

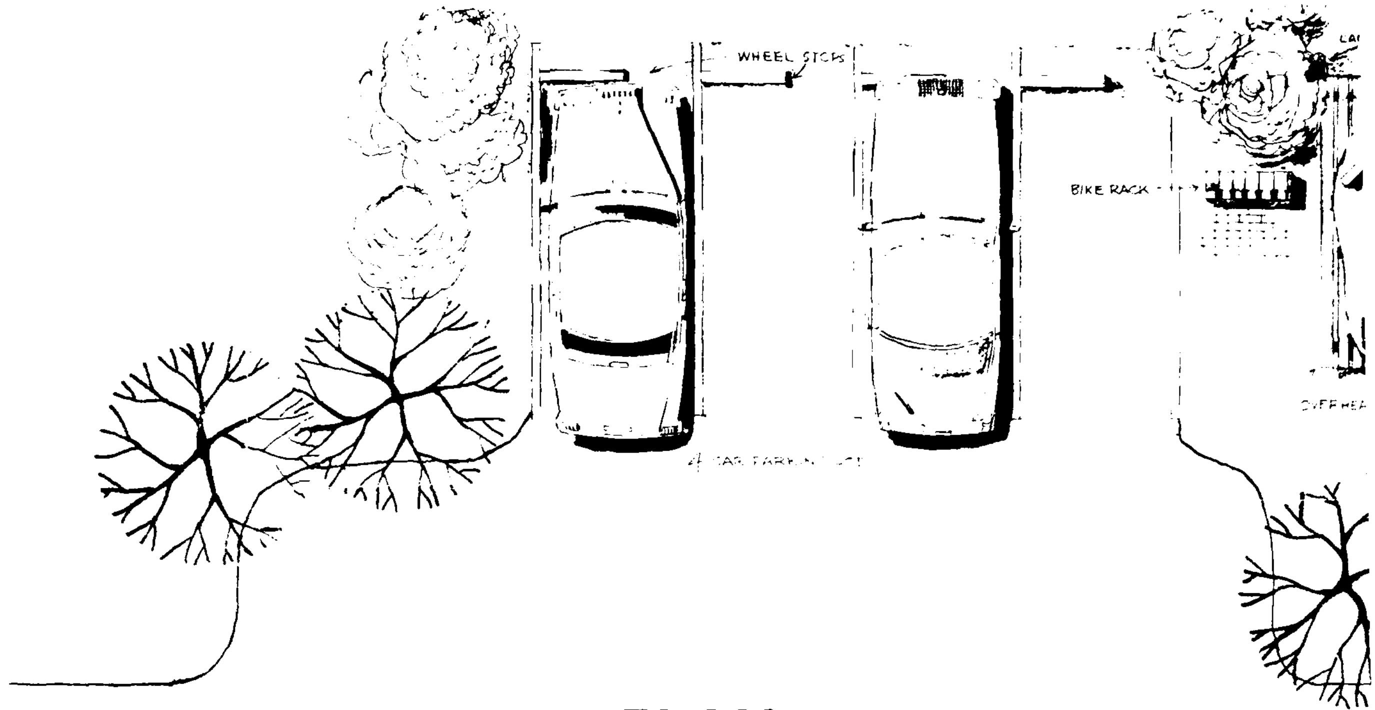
DATE APPROVED:

SPEC. NO. DACW09-____ B-____

DISTRICT FILE NO

SHEET ___ OF ___ SHEETS

PLATE B-3



PLAN

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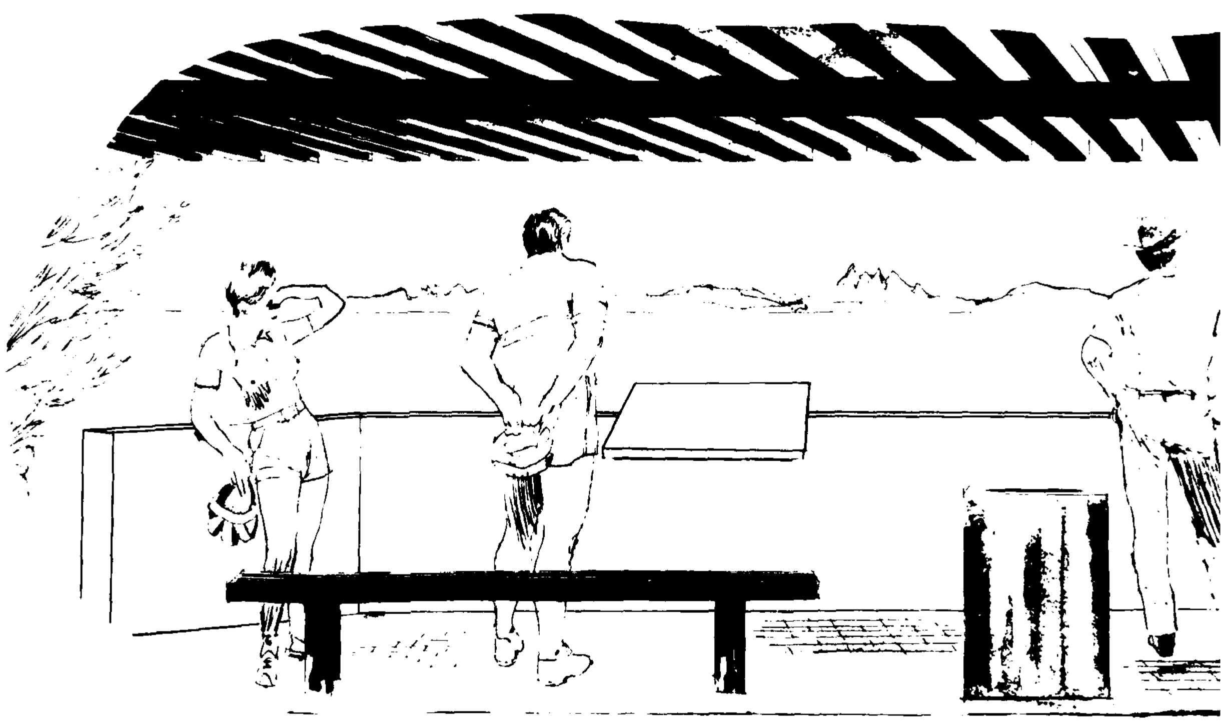
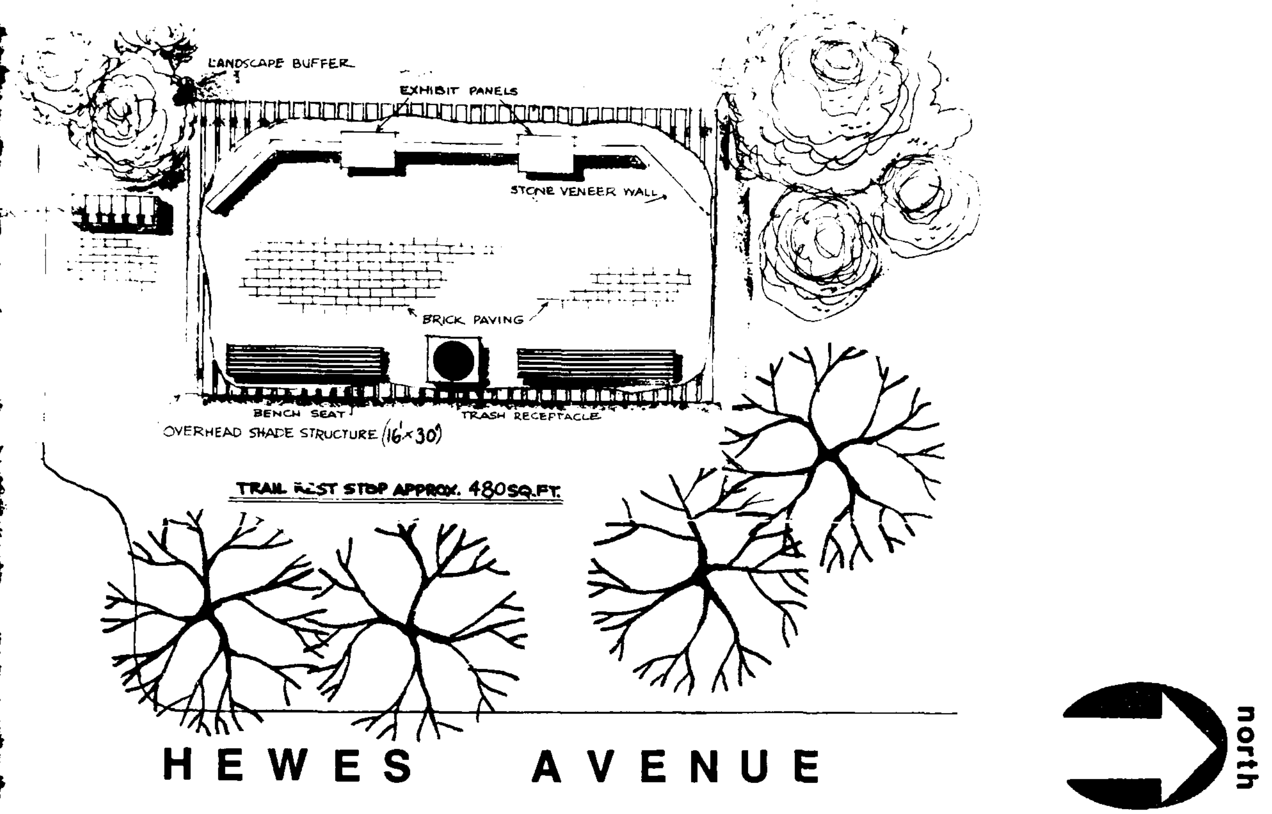
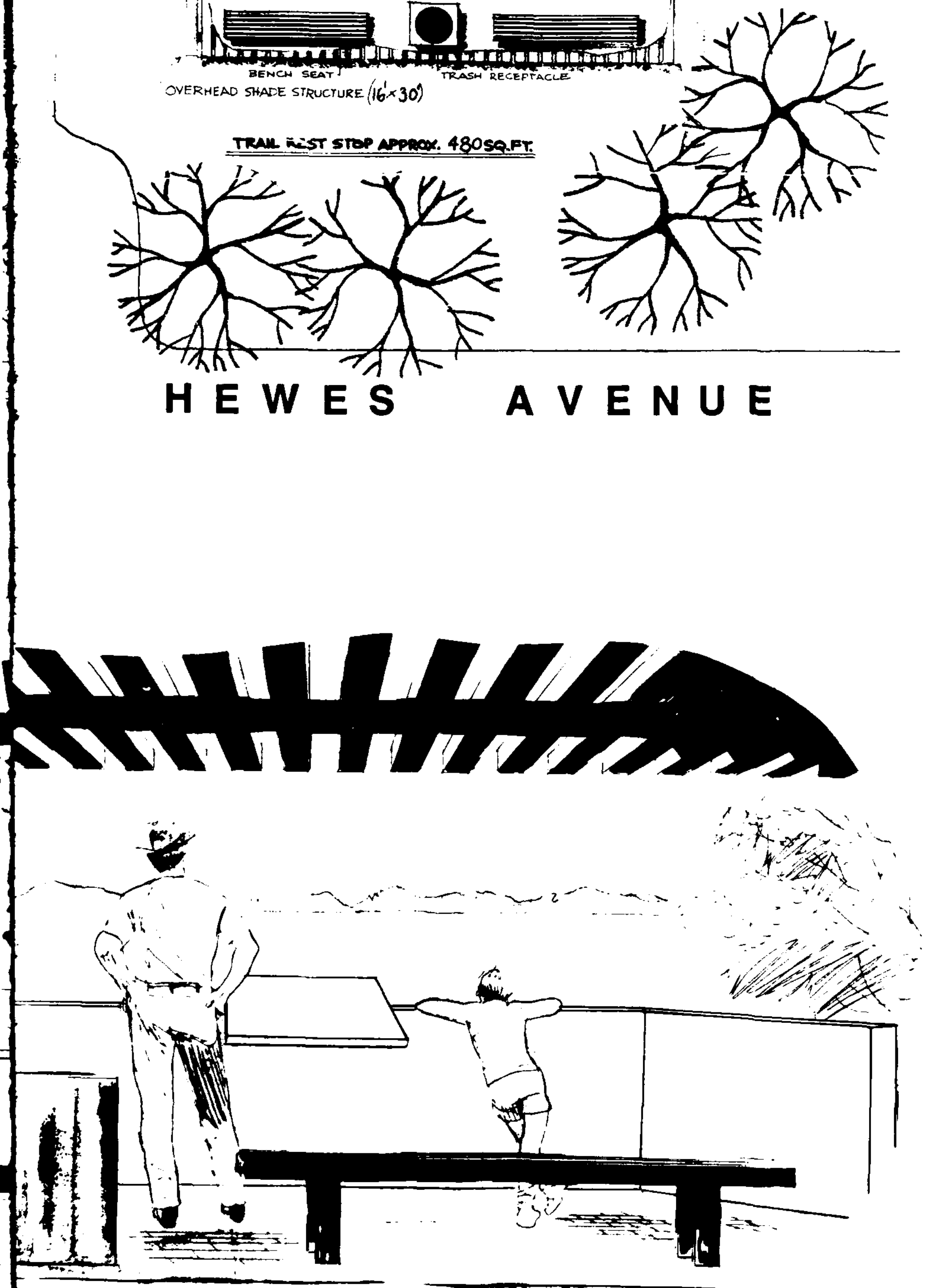


PERSPECTIVE





ECTIVE

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK CHANNEL

TRAIL REST STOP

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____-B-____
DISTRICT FILE NO
SHEET OF SHEETS
PLATE

CONTRACT BETWEEN
THE UNITED STATES OF AMERICA
AND
COUNTY OF ORANGE
FOR
RECREATION DEVELOPMENT
SANTIAGO CREEK FEATURE
OF THE
SANTA ANA RIVER FLOOD CONTROL PROJECT
SANTA ANA RIVER BASIN, CALIFORNIA

THIS CONTRACT entered into this_____ day of _____, 19__ by and between the UNITED STATES OF AMERICA (hereinafter called the "Government"), represented by the Contracting Officer executing this contract and the County of Orange (hereinafter called "County"),

WITNESSETH THAT:

WHEREAS, construction of the Santiago Creek feature of the Santa Ana River Flood Control Project, Santa Ana River Basin, Orange County, California (hereinafter called the "Project") was authorized by the Flood Control Act of 1944 (Public Law 534, 78th Congress); and

WHEREAS, pursuant to Section 4 of the 1944 Flood Control Act, as amended by Section 207 of the 1962 Flood Control Act, as amended (16 U.S.C. 460d), the Government is authorized to make contracts with non-Federal public bodies for development, management, and administration of the recreation resources of Federal water resources projects; and

WHEREAS, the office of Chief of Engineers has established certain policy for recreation development at Federal non-reservoir water resources projects consistent with Congressional intent as expressed in the Federal Water Resource Project Recreation Act of 1965 (Public Law 89-72).

NOW, THEREFORE, the parties agree as follows:

ARTICLE 1 - DEFINITION OF TERMS. For the purpose of this contract certain terms are defined as follows:

(a) First Costs: Used interchangeably with the terms "capital costs" and "project costs," are the initial capital costs of the recreation features of the project, including: engineering, design, supervision, and administration; land acquisition and construction.

(b) Recreation lands: Project lands acquired for flood control or other project purposes as described in a joint use agreement with the Flood Control District of Orange County

(c) Recreation facilities: Those facilities for recreation which may be installed pursuant to this agreement.

ARTICLE 2 - LANDS AND FACILITIES.

(a) The County is required to provide all recreation lands through a joint use agreement with the Flood Control District of Orange County (hereinafter called the "District"). Lands not required for the construction and operation of the flood control project are not subject to the provisions of this contract.

(b) The Government, in cooperation with the County, will prepare a mutually acceptable General Design Memorandum-Phase II which will depict and identify the types and quantities of recreation facilities which the Government and the County of Orange will construct in accordance with this contract. The presently estimated cost of facilities to be provided is contained in Exhibit A, entitled "Estimated Recreation First Cost", attached hereto and made a part hereof. Such estimate of facility cost is subject to reasonable adjustment as appropriate upon approval of the above mentioned Phase II - General Design Memorandum.

(c) The facilities as shown in Exhibit A, as it may be adjusted in accordance with paragraph (b) above, shall be constructed jointly by the parties through mutually satisfactory division of responsibility for construction that takes into account direct and indirect cost savings which may be gained by the parties in the public interest for certain specific facilities, provided, that the facilities to be constructed by each party shall be formally agreed upon by the two parties prior to construction, consistent with the provisions of Article 3.

(d) Title to all lands and recreation facilities constructed on flood control project lands, shall at all times be in the county and the county shall not transfer title to any non-public entity. The county shall, under this agreement, dedicate the land for recreation use.

(e) The performance of any obligation or the expenditure of any funds by the Government under this contract is contingent upon Congress making the necessary appropriations and funds being allocated and made available for the work required hereunder.

ARTICLE 3 - CONSIDERATION AND PAYMENT. Each party hereto will pay or contribute in kind fifty percent (50%) of the first costs of recreation development.

(a) Development. Fifty percent (50%) of the estimated first costs of recreation development is estimated to be $96,951.00. Prior to the advertisement of the first construction contract hereunder and again prior to the advertisement of each subsequent construction contract thereafter, the Government Contracting Officer shall calculate the estimated expenditures which each party shall have made up to the time of advertising of the applicable contract. If the total estimated expenditures by the Government shall exceed those of the County, the County shall pay to the Government such sum as will equalize the expenditures of both parties, prior to award of such contract. In computing expenditures, there shall be considered, in addition to cash expenditures, contributions in kind such as facilities, at the fair market value thereof at the time such land and facilities are provided, which value shall not include enhancement due to the project. Upon completion of recreation development, an adjustment will be made on the basis of actual costs incurred. It is understood and agreed that the County's share of the cost of the construction shall be computed on the basis of actual costs to the Government of the work included in the Government construction contract above and on the basis of unit prices in the Government contract and final quantities covering labor, materials, and equipment required for the work under the Government construction contract plus the actual amount, estimated at thirty-one percent (31), of the Government's costs for engineering, design, supervision and administration and not on the basis of prior estimates.

(b) Other Federal Funds. No payment credit of any kind whatsoever will be allowed the County for expenditures financed by, involving, or consisting of, either in whole or in part, contributions or grants of assistance received from any Federal agency in providing any lands or facilities for recreation enhancement hereunder.

(c) Adjustments to Reflect Costs. The dollar amounts set forth in this Article are based upon the Government's best estimates, and are subject to adjustments based on the costs actually incurred. Such estimates are not to be construed as representations of the total financial responsibilities of each of the parties.

ARTICLE 4 - CONSTRUCTION AND OPERATION OF ADDITIONAL FACILITIES. Certain types of facilities including but not necessarily limited to restaurants, lodges, golf courses, cabins, clubhouses, overnight or vacation-type structures, stables, marinas, swimming pools, commissaries, chairlifts, and such similar revenue-producing facilities may be constructed by the County or third parties and may be operated by the County or by third parties on a concession basis. Any such construction and operation of these types of facilities shall be compatible with all project purposes and shall be subject to the prior approval of the Contracting Officer. However, the County shall not receive credit for costs of such facilities against amounts due and payable under Article 3.

ARTICLE 5 - FEE AND CHARGES. The County may assess and collect fees for entrance to developed recreation areas and for use of the project facilities and areas, in accordance with a fee schedule mutually agreed to by the parties. Not less often than every five (5) years, the parties will review such schedule and upon the request of either, renegotiate the schedule. The renegotiated fee schedule shall, upon written agreement thereto by the parties, supersede prior schedules without the necessity of modifying this contractual document.

ARTICLE 6 - FEDERAL AND STATE LAWS.

(a) In acting under its rights and obligations hereunder, the County agrees to comply with all applicable Federal and State laws and regulations, including but not limited to the provisions of the Davis-Bacon Act (40 U.S.C. 276 a-a (7)); the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-333); and part 3 of Title 29, Code of Federal Regulations.

(b) The County furnishes its assurances that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 42 U.S.C. 2000d, et seq) and Department of Defense Directive 5500.11 issues pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations. The County agrees also that it will obtain such assurances from all its concessionaires.

(c) The County furnishes its assurances that it will comply with Sections 210 and 305 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646).

ARTICLE 7 - OPERATION AND MAINTENANCE. The County shall be responsible for operation, maintenance, and replacement without cost to the Government, of all facilities developed to support project recreation opportunities. The County shall maintain all recreation project lands, waters and facilities in a manner satisfactory to the Contracting Officer.

ARTICLE 8 - RELEASE OF CLAIMS. The Government and its officers and employees shall not be liable in any manner to the County for or on account of damage caused by the development, operation, and maintenance of the recreation facilities of the Project. The County hereby releases the Government and agrees to hold it free and harmless and to indemnify it from all damages, claims, or demands that may result from development, operation, and maintenance of the recreation areas and facilities. The County will not be responsible for Corps negligence or that of the construction contractor during the time the Corps is supervising such construction.

ARTICLE 9 - TRANSFER OR ASSIGNMENT. The County shall not transfer or assign this contract nor any rights acquired thereunder, nor grant any interest, privilege or license whatsoever in connection with this contract without prior approval of the Secretary of the Army or his authorized representative except as provided in Article 4 of this contract.

ARTICLE 10 - DEFAULT. In the event the County fails to meet any of its obligations under this agreement, the Government may terminate the whole or any part of this contract. The rights and remedies of the Government provided in this Article shall not be exclusive and are in addition to any other rights and remedies provided by law or under this contract.

ARTICLE 11 - EXAMINATION OF RECORDS. The Government and the County shall maintain books, records, documents, and other evidence pertaining to costs and expenses incurred under this contract, to the extent and in such detail as will properly reflect all net costs, direct and indirect, of labor, materials, equipment, supplies, and services, and other costs and expenses of whatever nature involved therein. The Government and the County shall make available at their offices at reasonable times, the accounting records for inspection and audit by an authorized representative of the parties to this contract during the period this contract is in effect.

ARTICLE 12 - RELATIONSHIP OF PARTIES. The parties to this contract act in an independent capacity in the performance of their respective functions under this contract and neither party is to be considered the officer, agent, or employee of the other.

ARTICLE 13 - INSPECTION. The Government shall at all times have the right to make inspections concerning the operation and maintenance of the lands and facilities to be provided hereunder.

ARTICLE 14 - OFFICIALS NOT TO BENEFIT. No member or delegate to the Congress, or Resident Commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefits.

ARTICLE 15 - COVENANT AGAINST CONTINGENT FEES. The County warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the County for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 16 - ENVIRONMENTAL QUALITY.

(a) In furtherance of the purpose and policy of the National Environmental Policy Act of 1969 (Public Law 91-190, 42 U.S.C. 4321, 4331-4335) and Executive Order 11514, entitled "Protection and Enhancement of Environmental Quality," March 5, 1970 (35 Federal Register 4247, Mar 7, 1970) the Government and the County recognize the importance of preservation and enhancement of the quality of the environment and the elimination of environmental pollution. Actions by either party will occur after considerations of all possible effects upon the Project Environmental Resources and will incorporate adequate and appropriate measures to insure that the quality of the environment will not be degraded or unfavorably altered.

(b) During construction and operation undertaken by either party, specific actions will be taken to control environmental pollution that could result from their activities and to comply with applicable Federal, State and local regulations concerning environmental pollution. Particular attention should be given to (1) reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases and smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) on and off site disposal of waste and spoil activities; and (5) prevention of landscape defacement and damage; and (6) reduction of groundwater mining through safe-yield pumping of wells.

ARTICLE 17 - EFFECTIVE DATE. This contract shall take effect upon approval by the Secretary of the Army or his authorized representative.

IN WITNESS WHEREOF, the parties hereto have executed this contract as of the day and year first above written.

THE UNITED STATES OF AMERICA	THE COUNTY OF ORANGE
By ______________________________	By ______________________
Colonel, Corps of Engineers District Engineer Contracting Officer	Chairman, Board of Supervisors
DATE ____________________________	ATTEST:
APPROVED:	______________________________ (Title)
______________________________	
DATE ____________________________	

Exhibit A
Estimated Recreation First Cost
Santa Ana River Mainstem,
(including Santiago Creek - County of Orange)
Santiago Creek Feature

Item No.	Description	Local Cost	Federal Cost
1.	Bicycle Trail	$44,616.00	$44,616.00
2.	Signs (Entrance/Directional)	$ 500.00	$ 500.00
3.	Traffic Control Signs	$ 500.00	$ 500.00
4.	Gates	$ 500.00	$ 500.00
5.	Parking	$ 4,251.00	$ 4,251.00
6.	Walk (5' x 20')	$ 100.00	$ 100.00
7.	Overlook Shelter	$12,500.00	$12,500.00
8.	Fountain	$ 600.00	$ 600.00
9.	Tree Planting	$ 595.00	$ 595.00
10.	Shrub Planting	$ 350.00	$ 350.00
11.	Trash Receptacles	$ 600.00	$ 600.00
12.	Benches	$ 200.00	$ 200.00
13.	Display Boards	$ 1,200.00	$ 1,200.00
14.	Irrigation System (Drip)	$ 1,665.00	$ 1,665.00
15.	Entrance Signs	$ 500.00	$ 500.00
16.	90 Days Maint. and Plant Estab. Period	$ 2,750.00	$ 2,750.00
17.	Seeding With Soil Preparation and Amend	$ 1,250.00	$ 1,250.00
	Subtotal	$72,677.00	$72,677.00
	Contingencies (15%)	10,901.00	10,901.00
	Subtotal	83,578.00	83,578.00
	Engineering and Design (10%)	8,358.00	8,358.00
	Supervision and Administration (6%)	5,015.00	5,015.00
	TOTAL RECREATION	$96,951.00	$96,951.00

Exhibit B

The undersigned, as chief legal officer for the County of Orange approves the foregoing agreement as to form and legality this ____day of __________ 19__. I have reviewed the contract in the light of the requirements of Section 221 of Public Law 91-611. I further find the County of Orange is a legally constituted body having full legal authority to enter into the foregoing agreement and to respond in damages in the event that it fails to fulfill its contractual obligations.

____
Title